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DEFINITION OF GAME RANGE DIVISIONS IN NEW YORK[1]

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ABSTRACT

In New York State, 11 game range divisions are delineated on the basis of differences in geology, topography, physiography, climate, soils, water areas, vegetation, land use, and the game species found or likely to succeed therein: Adirondack, Tug Hill, Ontario-St. Lawrence-Champlain, Erie-Ontario Lake Plain, Appalachian Plateau, Rensselaer Plateau-Taconic Mountain, Hudson Valley, Mohawk Valley, Catskill, Southeastern Highland, and Coastal Plain.

This study was undertaken in an effort to provide the wildlife administrator, the manager, and the research worker with a classification of New York State into the various game range divisions that may be distinguished on the basis of geology, topography, physiography, climate, soils, water areas, vegetation, and land use. Much of the basic information in these various fields has been available in the publications of State and Federal agencies, universities and colleges, and individuals, while some has existed only in manuscript form.

PROCEDURE

Efforts were made to obtain or review all of the published accounts regarding the physical characteristics of the State. These included publications of the New York State Museum relating to geology, botany, zoology, and archaeology, as well as the historical publications of the New York State Library, State publications on forestry, and the publications on land use, agriculture, forestry, and botany of the various State colleges. Information on land use and agriculture was obtained from the various State and Federal censuses. Information on the vegetative covering of the State was obtained in part from various scientific books and periodicals and from actual observations in the field, but primarily from such manuscript sources as the field books of the land surveyors of the eighteenth and nineteenth centuries.

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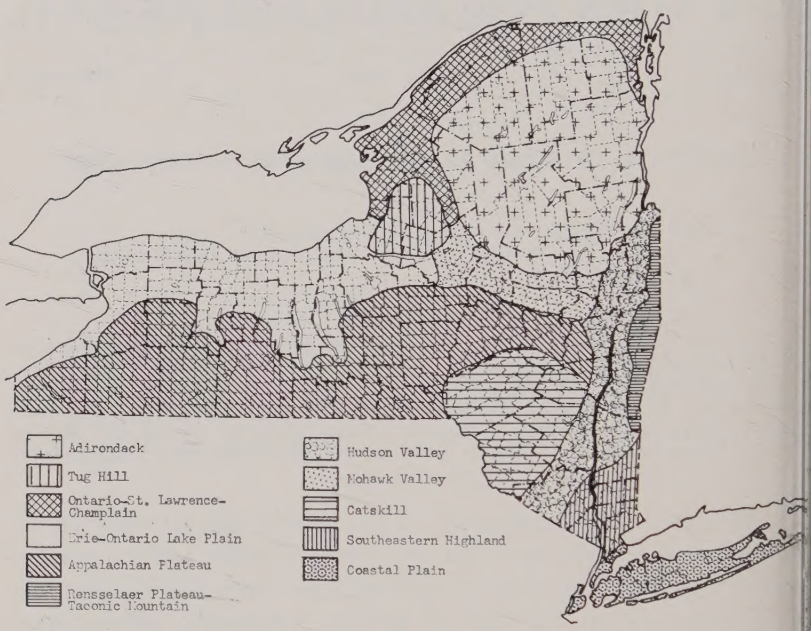

Figure 1. Major game range divisions in New York State.

Manuscript materials were either abstracted, copied, or recorded on standard topographic maps. These, plus the published materials were then adapted to a series of medium-scale (1:500,000) maps of the State. Where sufficient detail was lacking to complete a map of this scale, information was recorded on a series of 8 x 10 inch maps. This material was then utilized to construct the final map showing game range divisions for the State.

GAME RANGE DIVISIONS RECOGNIZED

The divisions recognized are shown on the accompanying map (Figure 1). Following are brief summaries of the characteristics of each as well as their potentials as game range.

Adirondack

The Adirondack division is characterized by mountainous topography, with elevations starting at about 1,000 feet[2] and reaching well

[2] Where this division reaches Lake Champlain the elevation drops to 95 feet

over 5,000 feet in the high peak area of Essex County. Most of it is above 1,500 feet. The underlying rock is nearly all igneous or metamorphic and, except for small pockets of crystalline limestone and the mass of lime-bearing anorthosite of the high peak area, has produced a thin, infertile, sandy soil generally classed as Gloucester.

The region has a mean annual temperature under 45° F., with a January and February mean of under 20° F. The average annual minimum temperature is −25° F. In July the mean temperature is between 60° and 68° F., and the growing season is between 90 and 130 days with that for most of the area being under 120 days.

Precipitation ranges from 60 inches annually on the western slopes exposed to the storms off Lake Ontario to 30 inches on the lee side of the mountain mass. The annual snowfall averages 80 inches or more, and is particularly heavy in parts of Herkimer and Lewis Counties where it is over 180 inches at some localities.

Under such conditions, the land area is suitable only for forests, which occupy nearly all of it. In general, the area below 1,500 feet is occupied by a northern hardwood forest of beech, yellow birch, sugar maple, hemlock, and paper birch, with an admixture of balsam fir and red spruce. The heart of the area is predominantly spruce, fir, and birch, becoming a stunted forest of spruce, fir, and paper birch on the exposed summits. On the highest peaks occurs the so-called Alpine flora, representing shrubs and herbs of the treeless areas far to the north. On the sands of the eastern Black River valley, and on the lowlands east of the higher mountains especially, white pine is an important species, being able to maintain itself against the hardwoods.

Game species to be considered in this zone are the white-tailed deer, black bear, varying hare, ruffed grouse, and woodcock. Of the important waterfowl, only the black duck breeds in substantial numbers here. The extensive coniferous forests still maintain precarious populations of spruce grouse and pine marten, and a recently expanding population of fisher. The beaver found its last refuge here, and since its restoration has prospered in recent years to the point of becoming a problem.

Tug Hill

The Tug Hill division must be considered an entity by itself since it is an elevated island of forest surrounded by agricultural areas. It covers southeastern Jefferson, northeastern Oswego, northwestern Oneida, and western Lewis Counties. The elevation is generally above

1,000 feet, with a crest at about 2,000 feet formed of Ordovician sand stones, conglomerates, and shales, which have produced an acid, sandy or stony, infertile soil that is very poorly drained both because of structure and as a result of the relatively flat topography of the top of the plateau.

The climate is generally unfavorable for agriculture, and better suited to forestry. It has a mean annual temperature under 45° F. with a January mean of about 20° F. and an average annual minimum of −20° F. The growing season averages under 145 days with a July mean under 70° F. The annual precipitation is between 50 and 60 inches, and snowfall is particularly heavy averaging 100 inches or more.

Elevations above 1,000 feet have remained largely in forest, although the lower elevations were extensively farmed until the end of the horse-and-buggy days. The forests of the poorly drained plateau top are red spruce, fir, yellow birch, and hemlock, grading down into the northern hardwoods type of beech, sugar maple, yellow birch, and hemlock.

Game species to be considered are white-tailed deer, varying hare and ruffed grouse. The black duck is the principal breeding waterfowl species in this division. The few cottontails that occur in the peripheral areas probably will disappear as more of the land reverts to forest. Beavers once occupied much of the area, finding the poor drainage conditions suitable for their impoundments.

Ontario-St. Lawrence-Champlain

This unit may be considered to start about at the Salmon River extending from the eastern end of Lake Ontario to where the winter moderating effect of the lake is largely lost at the western edge of the Adirondacks, and to comprise the lowlands there, including the Black River valley, and down the St. Lawrence valley and up the Champlain valley. It is limited on the east, south, and west by Tug Hill and by the Adirondacks. Its elevation is generally under 500 feet, although the Black River valley rises to 1,000 feet near its head. The underlying rocks are limestones and calcareous shales. The soils are generally classed as Vergennes clay, derived from glacial lake sediments, although the Black River soils are generally Ontario loam and associated series.

The climate is moderately severe with a mean annual temperature of 40° to 45° F. and a January mean under 20° F. The average annual

minimum ranges from −15° F. along the lake to −25° F. in the St. Lawrence and Lake Champlain valleys and −30° F. in the Black River valley. The average length of the growing season is between 160 and 140 days for the Ontario-St. Lawrence-Champlain portion, and down to 130 days for the Black River valley.

Annual precipitation varies from about 27 to 30 inches in the Champlain valley to about 50 inches in the Black River valley. It is interesting to note that the area occupied by Hungarian partridges in Jefferson and St. Lawrence Counties has less rainfall during the breeding season than does the adjacent territory. Snowfall varies considerably, likewise, from 40 to 60 inches in the Champlain valley and along the St. Lawrence River to generally under 80 inches elsewhere, except that the eastern end of Lake Ontario and the Black River valley receive from 100 to 160 inches.

The forest cover of this division is a modification of the Adirondack phase of the northern hardwoods type comprising beech, sugar maple, basswood, hemlock, and the northern birches, with red, white, and bur oaks along the two lakes and the St. Lawrence River, and with extensive arborvitae swamps in the limestone areas. Because of the medium to high productivity of the Vergennes and Ontario soils, over 80 per cent of the area is still in farms, primarily devoted to dairying. The growing season is rather short for growing corn for grain, but considerable silage corn is grown, along with oats and mixed grains. In recent years an increased amount of winter wheat has been grown in Jefferson County, probably in response to price supports. This is also a principal hay producing region, because of the dairy requirements.

Game species to be considered are Hungarian partridge, ring-necked pheasant, ruffed grouse, cottontail rabbit, gray squirrel, varying hare, and white-tailed deer. This region is important as a breeding ground for the black duck, mallard, and wood duck, while its water areas rank high for waterfowl shooting. Substantial numbers of diving ducks winter in the eastern end of Lake Ontario.

The Hungarian partridge has become established since 1930 in the grain-growing areas of Jefferson, St. Lawrence, and Franklin Counties. In addition to grain production, factors possibly influencing its success in this territory are the somewhat lower breeding season precipitation, the lower amount of snowfall, and the strong prevailing winds in winter which tend to keep stubble fields bare or thinly snow covered. Attempts might well be made to transplant this species to other parts of this range division where conditions are similar.

Pheasants and cottontails both represent fairly recent additions and seem near the limits of their range here, in that their numbers declined considerably after 1939 and have not since reached their former level. The cultivated nature of the range precludes large populations of grouse, hares, and deer.

Erie-Ontario Lake Plain

The Erie-Ontario Plain is generally bounded on the south by the 1,000 foot contour, and includes the Genesee valley and the lowlands of the major Finger Lakes. It extends east to the Salmon River, and along the south side of Oneida Lake to the Oneida-Mohawk divide. It is very narrow along Lake Erie, but broadens into a gently rising plain from an elevation of 246 feet to the heads of Seneca and Cayuga Lakes.

The underlying rocks are the limestones and shales of the upper Ordovician, Silurian, and Middle Devonian periods, from which have been derived the moderately to highly productive soils of the Ontario, Palmyra, Dunkirk, and Genesee soil areas—the soils formerly identified as Worth in Monroe, Wayne, Cayuga, and western Oswego Counties—as well as the muck soils of the Salina depression from Niagara to Oneida Counties.

The climate is considerably moderated by being in the lee of two of the Great Lakes, only the extreme lower Hudson valley and Long Island being more equable. The mean temperature is 40° to 45° F. with a January mean of 20° to 25° F. The mean October temperature of 50° to 55° F. delineates the area quite well and shows the moderating effect of the lakes. The average annual minimum ranges from $-5°$ F. near the two Great Lakes to $-15°$ F. east of Oswego, south of Oneida Lake, and in the middle Genesee valley.

The growing season ranges from at least 150 days to as high as 180 days at Oswego. Precipitation averages 30 to 40 inches but is under 30 inches in two areas, i.e., in northwestern Niagara County and in Wyoming and Livingston Counties eastward into Yates County. Snowfall ranges from slightly over 40 inches in the two areas just mentioned to around 100 inches east of Oswego, and averages under 80 inches.

The original forest cover of the Erie-Ontario Plain is classed as central hardwoods, composed of beech, sugar maple, basswood, black birch, white ash, and yellow poplar or tulip, with a mixture of white, black, red, bur, and swamp white oaks and chestnut on the drier sites.

Hemlock was common only along the Great Lakes and along ravines and in swamps. Ash, elm, maple, and alder swamps were frequent. Some swamps were occupied by arborvitae, while extensive areas in Genesee, Seneca, and Cayuga Counties were still in the cattail stage. White pine was limited to swampy areas, likewise.

The larger proportion of this unit was cleared for agriculture and still remains intensively cultivated. The proportion of land in farms in 1950 ranged from 55 per cent in Erie County and 66 per cent in Monroe and Onondaga Counties, where large areas are urban and suburban, to 81 per cent in Wayne County.

This is the chief cash crop area of the State, producing most of the corn for grain, winter wheat, dried beans, cabbage, tomatoes, and substantial proportions of the other vegetables for sale. The fruit industry is chiefly concentrated in the lee of Lakes Erie and Ontario and about the Finger Lakes, because of moderate climate and good soils.

This is the principal range for so-called farm game, the ring-necked pheasant and the cottontail rabbit. The former was first successfully introduced in the Genesee valley and has consistently maintained its numbers in this area alone. The cottontail extended its range into this region about 1880 and has become numerous enough to constitute a periodic nuisance in the fruit belt. The gray squirrel is abundant in the oak-hickory and oak-chestnut forest remnants along the southern margin of the Lake Plain area. The white-tailed deer has extended its range north to Lake Ontario since 1930, which has brought it into conflict with agriculture. The bobwhite quail, during the great wheat producing era of the nineteenth century, extended its range into this area, but apparently could not maintain itself because of frequent unfavorable winters. The fertile marshes of the Salina depression long have been noted for their muskrat production. This region is an important waterfowl breeding area for New York, the principal species being black duck, mallard, wood duck, and blue-winged teal. It provides many hunting opportunities for both marsh ducks and diving ducks, and is second only to the Coastal Plain as a waterfowl wintering ground.

APPALACHIAN PLATEAU

The Appalachian Plateau occupies the territory between the New York-Pennsylvania line and the Lake Plain, and extends between the Mohawk valley and the Catskills to the Hudson valley. It lies chiefly

above the 1,000 foot contour, with a skyline at about 2,000 feet, and rises to a maximum of over 2,500 feet in southern Allegany County. It is an ancient peneplain dissected by numerous streams. The rocks are chiefly middle and upper Devonian sandstones and shales. The unglaciated area adjacent to and south of the Allegany River is sometimes designated as the Allegheny Plateau, but is here considered part of the Appalachian Plateau.

The soils are shallow, generally acid, poorly or only moderately well drained and are largely influenced by the underlying rock. They are mostly classed as Volusia, Mardin, Langford, Cattaraugus, and De Kalb soil areas, but the valley soils are generally grouped in the Chenango soil area representing the accumulation of more fertile materials.

The climate is more severe than that of the Lake Plain, but not so much so as that of the Catskills. The mean annual temperature ranges from 50° F. in the valleys to about 40° F. in the Allegany State Park region. The January mean varies from 20° to 25° F. and the average annual minimum from −15° to −20° F., except in the Susquehanna-Finger Lakes valleys area where the minimum is −10° to −15° F.

The average length of the growing season ranges from about 100 days in Allegany State Park to over 150 days in the lower Susquehanna valley and near Lake Erie. Much of the hill country averages 135 days or less, which limits the crops to be grown.

Precipitation is 30 to 40 inches annually, about half coming during the growing season. Snowfall averages 40 to 80 inches, being less in the valleys and greater on the hilltops.

The original forest was what may well be called the Alleghanian phase of the northern hardwoods type, comprising beech, sugar maple, basswood, hemlock, black cherry, red oak, black birch, and cucumber, with abundant white pine where well drained soils and occasional fire enabled it to maintain itself. On the sides of the broader valleys the oaks, hickories, and chestnut were locally dominant, and were intermingled with the northern hardwoods at higher elevations. At elevations over 2,000 feet, the Alleghanian hardwoods passed into the more northern phase of beech, maple, hemlock, and yellow birch, particularly in the eastern part of this range.

Much of this division was cleared for farms in the last century, but poorly drained, quickly impoverished soils, a short growing season, and the decline of the horse-and-buggy economy led to almost headlong abandonment after 1920. Between 1935 and 1950 in Steuben and Chemung Counties, farm acreages declined over 15 per cent. The

remaining farms probably will continue, being fairly well suited to dairying.

Game species in this region are white-tailed deer, ruffed grouse, woodcock, cottontail rabbit, and gray squirrel. The reversion to forest has proceeded far enough so that varying hares have been successfully established in several areas. The movement of wild turkeys from Pennsylvania has indicated that it may be possible to reestablish this species in the Southern Tier counties. Small populations of Hungarian partridge have maintained themselves in the wheat-producing areas along the northern margin of the region. Ring-necked pheasants are fairly successful only in the larger valleys, while all attempts to establish bobwhites have failed. This is less important than the preceding division as a waterfowl breeding area, although the Department's small marsh development program offers much promise for greater waterfowl production.

The greatly varied habitats developed, as cleared land has slowly reverted to forest, have permitted a tremendous increase in the abundance of deer, but the pressure on the vegetation is already so great that frequent heavy reductions in deer numbers are necessary to prevent serious damage to the vegetation and to crops, and to keep the deer population in a healthy, vigorous state considerably below the absolute carrying capacity of the land.

The cottontail population likewise expanded greatly as the vegetative cover changed, but, as the forest begins to close in and shade out the ground plants, a decline in cottontail numbers must take place. Fortunately, varying hares seem ready to replace them as the cover becomes more suitable for the hares.

Rensselaer Plateau-Taconic Mountain

The Rensselaer Plateau-Taconic Mountain division is considered as a unit because of similarity in climate, elevation, and vegetation, although geologically the two component areas differ. Both are elevated and rugged, rising from about 1,000 feet to over 2,000 feet on the Rensselaer Plateau and up to 2,500 feet at the top of the Taconics. The Rensselaer Plateau is capped by sandstone and conglomerate, similar to but probably older than the Devonian delta exposed in the Catskill Mountain sediments. The Taconics are made up of metamorphosed rocks of Cambro-Ordovician age, appearing as slates, marbles, and the like.

The soils developed from the conglomerates and sandstones are

classed as Hermon, associated with the Gloucester soil area, but should be classed otherwise, since they are not derived from crystalline rocks. The soils are stony and acid, and the drainage is poor. The soils of the Taconics are moderately productive where they can be cultivated.

The mean annual temperature ranges from 45° to 50° F. for the valley stations nearby, but the area within this range division probably has a lower mean because of its elevation. The January and July means appear likewise lower than those for the valley. The average annual minimum temperature is under −20° F., and the lowest temperatures fall between −30° and −40° F. The length of the growing season is under 145 days. Precipitation averages 40 to 50 inches, while the mean annual snowfall is greater than the 60 to 80 inches recorded from nearby valley stations.

The topography of the area is such that much of it has remained in forest, whereas many portions formerly cleared are now reverting to forest. The elevations above 2,000 feet are occupied by forest composed of red spruce, fir, yellow birch, and paper birch, mixed with beech, sugar maple, hemlock, and white pine, so that this is an outlier of the Adirondack and Green Mountain forests.

Game species to be considered are white-tailed deer, black bear, varying hare, ruffed grouse, and, around the margins of the range, gray squirrel and cottontail rabbit, although there is evidence that the latter actually move down into the valleys in severe winter weather. The poorly developed drainage of the Rensselaer Plateau has been suitable for beaver. A few waterfowl, principally black ducks and wood ducks, breed in the region.

Hudson Valley

The Hudson Valley region extends north to the vicinty of Glens Falls and south to the Southeastern Highlands through which the river has cut its rocky gorge only recently in geologic time, and where the ancient valley swings southwest into New Jersey. It is terminated on the west against the Adirondacks and the Catskills and on the east by the Taconics and the Rensselaer Plateau.

The underlying rocks are intensely folded Cambrian and Ordovician shales and Silurian and lower Devonian limestones and shales. The soils are derived from lacustrine clays (Vergennes soils), from fine aeolian sands from the postglacial drainage off the Adirondacks (Claverack and Colonie soils), from the Cambrian and Ordovician rocks (Dutchess soils), and from limestones and calcareous shales (Ontario and Chenango soils).

The climate is moderated by the low elevation, with a mean annual temperature ranging from about 45° F. at Glens Falls to nearly 50° F. along the margin of the Southeastern Highlands. The January mean similarly ranges from 20° to nearly 30° F. The average annual minimum at Glens Falls is −20° F., at Albany −10° F., and at Beacon −5° F. The July mean is 70° to 75° F. The growing season varies from 150 days at Glens Falls to about 180 days at the Highlands.

Rainfall is 40 to 50 inches around Glens Falls and south of the Catskills, and 30 to 40 inches in the middle Hudson valley. Snowfall decreases from about 70 inches at the north to about 40 inches at the south.

The original forest was of the oak-chestnut type and extended from Glens Falls south, modified on the sand plains into a white pine-pitch pine-oak association, and by fire into a pitch pine-oak-scrub-oak disclimax also found on the Shawangunk ridge to the south. Most of the land was cleared for agriculture, and the valley lands are still devoted to general farming, truck gardening, and fruit growing, especially along the Hudson River south of Albany. Farm acreage in Albany County has declined 16 per cent since 1935, but most of this has occurred on the hills and where residential expansion has taken place. Farm acreage in Dutchess County has declined only 5 per cent in the same period.

Heath hens, bobwhite quail, and wild turkeys once occupied the more open areas of the oak-chestnut and pine-oak forest, but all of these have disappeared, except perhaps the bobwhite quail in the extreme southern part of the Hudson valley. At present the range supports moderate numbers of ring-necked pheasants and cottontail rabbits, considerable numbers of gray squirrels, and a few ruffed grouse which are more numerous near the east and west margins. A few European hares still survive from the expanding populations of the early 1900's in the lower Hudson valley. The black duck, mallard, and wood duck are the principal breeding waterfowl. The marshes along the Hudson River provide many good hunting grounds.

Mohawk Valley

The Mohawk Valley division is essentially the Mohawk Section of the Appalachian Plateau Physiographic Province, consisting of a very narrow east-west valley whose walls level off at about 600 feet elevation and which extends to meet the Adirondack region on the north and the Appalachian Plateau region on the south. The underlying rocks are generally Ordovician and Silurian limestones and shales

from which have developed soils of the Ontario, Cossayuna, an Chenango groups.

The climate is cooler than that of the Hudson Valley division having a mean annual temperature of 40° to 45° F. and a January mean of 15° to about 22° F. The average annual minimum range from −15° to −20° F. at most of the stations, and the mean minimum for February from 5° to 10° F. The length of the growing season varies from about 140 days to about 155 days near the Hudson Valley.

Precipitation is about 30 to 40 inches annually, while the annual snowfall averages 40 to 80 inches. Unlike the middle and lower Hudson valley, the winter snow cover is fairly persistent.

The forest cover originally was predominantly beech, maple, and hemlock, with oaks and hickories on the south-facing slopes, so that it was intermediate between the two phases of the northern hardwood type. Most of the land is under cultivation, e.g., Montgomery County which had 78 per cent of its area in farms in 1950. Dairying is the principal farm occupation, and the small acreage of cash crops is grown primarily on the valley bottom lands. A moderate amount of winter wheat has been grown in recent years in the region.

The area supports only small populations of pheasants, nearly all on the bottom lands where grains are grown. Cottontail and deer populations are small and varying hare populations are localized. A few black ducks and wood ducks breed here. This is an area in which Hungarian partridges might well be tried as "transplants" because of the similarity of its soils, land use, and climate to those of the territory occupied by this species in the Ontario-St. Lawrence-Champlain division.

Catskill

The Catskill division is composed of the conglomerates, sandstones, and shales of an ancient delta, and covers western Greene, western Ulster, and most of Sullivan and Delaware Counties. Most of it lies above 2,000 feet, with a few elevations over 4,000 feet. The conglomerates and sandstones have produced stony, sandy, acid, moderately fertile to poor soils designated as the Lackawanna and Culver soil areas, with the more fertile soils in the bottoms of the deep valleys. On the east, the area is limited by the abrupt escarpment at the edge of the Hudson valley, and on the west by the Susquehanna valley.

The mean annual temperature is between 40° and 45° F. with a January mean of 20° to 25° F. The average annual minimum varies

from −15° to −20° F. The growing season averages 120 to 150 days, with a mean July temperature of 65° to 70° F.

The annual precipitation averages 40 to 50 inches, with about half of it occurring in the growing season. Annual snowfall ranges from 40 to over 60 inches.

The original forest cover above 2,000 feet was northern hardwoods characterized by beech, sugar maple, hemlock, and yellow birch, with an admixture of fir, red spruce, and paper birch at the higher elevations and white pine on the gravelly stream terraces. At lower elevations there was an intermingling of black cherry and the northern oaks. Extensive destruction of hemlock for tanbark, and clear cutting for acid wood, have left vast acreages occupied principally by three species, i.e., beech, sugar maple, and black cherry.

The valley soils are fertile enough so that they probably will remain in cultivation, but there has been a decline in the area of land in farms in the 15 years between 1935 and 1950, varying from 6 per cent in Delaware County to 15 per cent in Sullivan County. In recent years this has not meant abandonment, but a change from agriculture to summer residences, hunting camps, and other recreational uses.

The game species to be considered are the white-tailed deer, black bear, ruffed grouse, and varying hare. Cottontail rabbits probably will maintain themselves in the cultivated areas, but the ridge-and-valley terrain and dairy farming are not suited to ring-necked pheasants. Experience in other states with wild turkeys in the Alleghanian type of northern hardwoods indicates that this former resident could be reestablished in modest numbers in all but the higher forest areas. Although a few black ducks and wood ducks breed, waterfowl are of minor importance here.

Southeastern Highland

The Southeastern Highlands have been breached by the Hudson River in recent geologic times and are usually considered part of its valley. However, the crystalline rocks comprising the Highlands are quite different from the Hudson valley sedimentaries, and the resulting rocky, rough terrain sets them apart. The soils are thin, acid, sandy or stony, of low fertility, and are considered related to the Gloucester soils of the Adirondacks.

The climate, because of the proximity to the ocean, is milder than that of the Hudson valley to the north. The mean annual temperature ranges from about 48° to 50° F., with a January mean of 25° to

30° F. and an average annual minimum of −15° F. in the northern portion to 0° F. in the southern portion. The growing season averages 165 days to 195 days. The annual precipitation is 40 to 60 inches, with an annual snowfall of about 30 to 50 inches.

The original forest was of the oak-chestnut type, with an admixture of beech, maple, and hemlock from the north, and tulip tree from farther south. Originally much of the less rugged land was cultivated but decline of the hay and fodder market caused a reversion to woodland which is now mostly held in country estates.

During the heyday of agriculture, bobwhite quail populations were present but these have almost disappeared. Squirrels, grouse, deer and to some extent cottontails, are the species to be considered in this unit at the present time.

Coastal Plain

The rapid conversion to residential areas of western Long Island and Staten Island (which is not properly part of the Coastal Plain but is climatically similar) leaves only Suffolk County for consideration as game range. The elevation of the latter varies from sea level to 420 feet with most of the area under 100 feet. Two ridges—considered by some to be two terminal moraines from the Pleistocene glaciation, and by others to be upwarped Cretaceous gravels displaced by the weight of the glacial ice—form the north and south "flukes" of the whale-like shape of the island.

The soils are generally derived from the gravels, which had their origin in crystalline rocks, so that the soils are sandy, acid, and well to excessively drained. The Hempstead loam, now pretty well covered by settlements, was developed from a grassland of considerable persistence.

The climate is the mildest in the State, being moderated by the surrounding oceanic waters. The mean annual temperature is over 50° F., except for the eastern extremity which is slightly cooler. The January mean is 30° to 35° F. while the average annual minimum is 0° F. The July mean is 70° to 75° F. The average length of the growing season ranges from 180 days in the pine and oak barrens to 209 days at New York and 210 days at Setauket on the hills of the north shore.

The mean annual precipitation is 40 to 50 inches. Snowfall is 20 to 40 inches on an average, but because of the moderate climate a snow cover seldom lasts more than a few days.

Formerly the area of the Hempstead loam in Nassau County was treeless, apparently for a long time, and occupied by grasses and forbs found in the tall grass prairie of the Midwest. Surrounding it was a brushy oak and shrub area that graded away into normal forest and which extended eastward into Suffolk County. The central part of the island east to Wading River was an oak-pitch pine forest that two centuries of burning and cutting have depauperated to its present state. The hills of the north shore are principally oak forest. The mild climate permits the existence of a number of plant species, such as post oak, sweetgum, pin oak, American holly, and persimmon, that are normally more southern in their distribution.

Formerly the Hempstead Plains and the brushy plains surrounding them were the range of the heath hen, bobwhite quail, ruffed grouse, white-tailed deer, gray squirrel, and probably the cottontail rabbit. The heath hen disappeared by 1840, while the bobwhite maintains a population level in the forest margins that is obscured by liberations of farm-reared birds. The deer population maintains itself at a nuisance level about the truck gardening areas, but human population density and other local considerations have kept the season closed. The cottontail population is large enough to cause damage complaints periodically, while ruffed grouse numbers are negligible. The length of the ring-necked pheasant season would seem to be a reflection of the interest in this species and the operation of shooting preserves, rather than the suitability of the area for it, since only 20 per cent of Suffolk County is classed as farmland.

The coastal waters and streams support moderate breeding populations of mallards, while black ducks and wood ducks are few and local in their breeding. Large numbers of ducks and geese stop in Long Island waters during both spring and fall migrations. This region is also the chief wintering ground in the State for waterfowl, notably the scoters, scaups, and black duck. Hence it is important as a hunting area in fall and early winter.

PRELIMINARY STUDIES OF MENHADEN AND THEIR MASS MORTALITIES IN LONG ISLAND AND NEW JERSEY WATERS[1]

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ABSTRACT

Since 1947, several thousand samples of menhaden *(Brevoortia tyrannus)* from commercial catches in the New York bight have been examined, plus several thousand "zeros" (young-of-year) from Long Island and New Jersey waters. Menhaden appear in large numbers in these waters during April, with heavy concentrations in the inner New York bight. Scale studies have indicated that prior to 1953 these first runs of fish were largely composed of 3- and 4-year-olds, with some fives and occasional sixes. Large numbers of 2-year-olds appeared in late May or June and soon dominated the catches. In 1953, large numbers of "yearlings" appeared in local waters during April and these, together with an early influx of 2-year-olds, dominated the catches by numbers.

Menhaden apparently spawn from June to September in the coastal waters of Long Island and New Jersey. Evidence suggests that many 2-year-olds, both male and female, spawn by late summer; and a small minority of the 1-year-old males from the 1953 catches showed evidence of approaching maturity. All menhaden examined that were 3 or more years of age appeared to be adults. Young appear in great numbers in tidal rivers, canals, and estuaries and often reach a size of 5 inches by late September when they migrate to the ocean.

An annual, heavy mortality of menhaden in the waters adjacent to New York Harbor occurs in late May and June when millions of fish die and litter the beaches. Dying fish, called "spinners", are characterized by a loss of coordinated movements and exopthalmia of one or both eyes. Hemorrhages, caused by gas emboli, were noted in the capillaries of the gills, eyes, and optic lobes of the brain.

Menhaden along the Atlantic coast of North America are susceptible to a variety of parasites which, especially those found on the gills, may contribute to the mass mortalities observed.

Federal statistics indicate that the menhaden fishery is presently the largest fishery, by weight, in the United States. Some 800,000,000 pounds of this clupeid—or more than a billion fish—are harvested during a good year from our Atlantic and Gulf coasts. Neither a food nor a game fish, the menhaden—or pogy, mossbunker, 'bunker, or fatback, as it is often called—is processed into fish meal, scrap, and oil.

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[1] The writers wish to express their thanks to the following: The New York State Conservation Department for permission to include much of the data obtained from 1946 to 1949; Protector Andrew Zimmer of the New York State Conservation Department for his assistance with the field work; Mr. E. M. Pollack, presently of the Massachusetts Division of Fish and Game, for his assistance in procuring data; Mr. C. M. Cubbage and the J. Howard Smith Company for their constant interest and assistance in procuring data; and Mr. Paul Hamer of the New Jersey Division of Fish and Game for his assistance in reading scale samples.

hich in turn enter into a host of products utilized by man—from oultry and eggs on the one hand, to preservatives and linoleums on ie other. In addition, thousands of tons of ground-up mossbunker re thrown into the water as chum for bluefish, tuna, mackerel, and bacore each year by the salt-water anglers of New York and New rsey. In the New York State Conservationist the authors (1950) rmed the menhaden the "Atlantic Schmoo", as contrasted to the pig, ecause "the 'bunker has no squeal and everything is used period".

Because of the great size of the menhaden fishery, and because it fects so many persons in our country, one might expect this fish to the most heavily researched of all marine species. Paradoxically, owever, little is known about the menhaden. While such relatively significant marine fisheries as those for shad, striped bass, and the usive, Atlantic bluefin tuna have been receiving much attention and idy, the nation's leading fishery remains largely under a veil of ystery. Aside from the taxonomic studies of Hildebrand (1948), the opular account of Roy (1949), and assorted notes by other investiitors, the menhaden seems to have been a species much taken for anted. Scattergood, Trefethen, and Coffin (1951), in reporting on enhaden in Maine waters, have mentioned this dearth of knowledge out our nation's principal marine fish.

Hildebrand (1948) recognized seven American species of menden, and if our impatient taxonomic efforts are accurate, the approximately 250,000,000 pounds taken in Long Island and New Jersey aters each year are composed of the species *Brevoortia tyrannus*.

Menhaden appear in the New York bight in commercial quanies during late March or April and, according to reports received, e large fish precede the smaller fish by several weeks. During the tter part of May, or early June, great quantities of menhaden die in ese waters and in the waters of western Long Island Sound, and litter e beaches in untold numbers. Consequently, various agencies call other encies each year, or write letters, about this phenomenon. These encies, in turn, communicate with other agencies which, in turn, ay refer the problem back to the first agency, and so on.

THE PROBLEM

The authors have been interested in, and studying, menhaden ce 1945. During 1946, samples of several hundred menhaden were en from commercial catches for exploratory study. These studies dicated that, except for certain difficulties in determinations of age, d of "ripeness" of the gonads, the species was susceptible of study

along conventional lines. Accordingly, a program of investigation wa started by the New York Conservation Department during 1948, an has been continued by the State University of New Jersey, in collab oration with the New York Zoological Society, since 1949.

The preliminary problems investigated by the authors are six i number, namely:

1. Can orthodox methods of scale analysis and length-frequenc compositions be used with the species?
2. What are the age compositions and growth rates of menhade taken in Long Island and New Jersey waters?
3. Are there seasonal changes in these age, or size, composition as reported?
4. What is the extent of spawning in these waters and how lon do the young remain?
5. What are the possible causes of the annual mass mortalities o menhaden in certain areas?
6. What parasites infest menhaden?

PROCEDURE

After the preliminary studies of the lengths and scales of men haden from commercial catches during 1946 and 1947, together wit examinations of "spinners" (dying menhaden), a regular samplin program was designed for 1948 and 1949. This program consisted o taking samples from commercial catches each week, together wit regular samples of "zeros" (young-of-the-year) found in tidal river tidal creeks, and canals and yacht basins of estuaries. Since 1949, othe samples have been taken—both from commercial catches and fro the zero populations in New Jersey waters. Lengths were measure to the nearest half-centimeter, from the tip of snout to fork of tai In all, some 6,000 specimens of menhaden have been studied, includ ing approximately 1,200 scale samples from these fish.

About 250 of the scale samples, including most of those use for the study of differences between the growth rates of the sexe (Table 1), were first read independently by two persons. The area o agreement, however, was so close that this practice was discontinue and only one person continued the scale reading.

Dissections and detailed examinations were made of numbers o spinners during the annual mass mortalities in the waters of the inne New York bight. Cultures were made of the scales of these menhade to test for the presence of fungus infections, and stomachs and in

estines were fed experimentally to immature house cats to test for the resence of toxic plankton.

RESULTS

It was discovered that the scale samples from most of the menaden could be read with some difficulty, while some appeared to xhibit clearly defined annuli (Figure 1). Direct reading under the

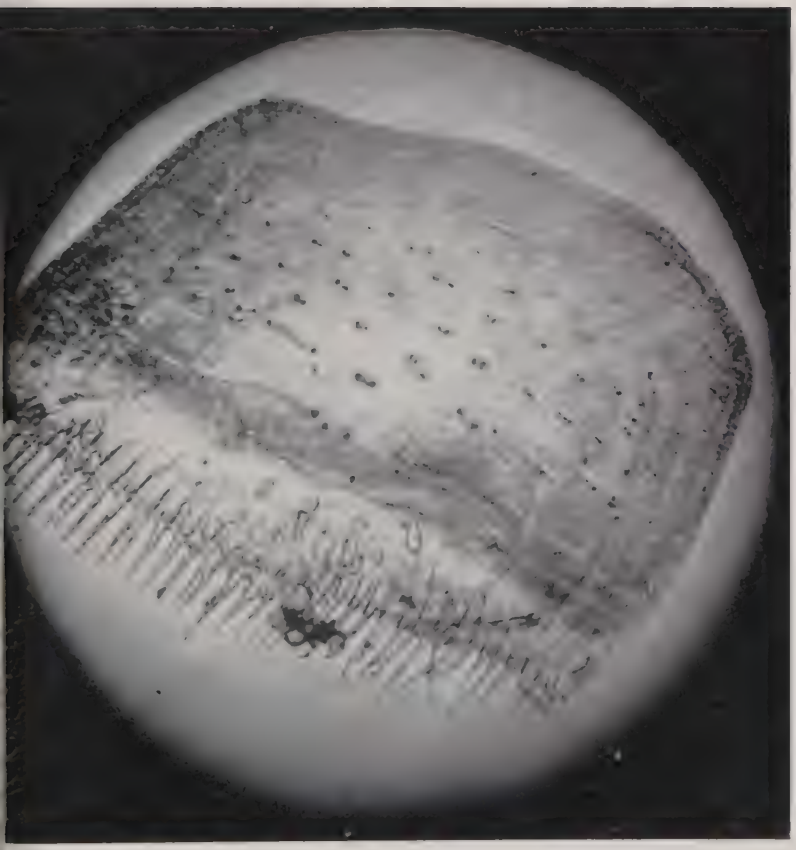

Figure 1. Scale of menhaden showing three annuli.

nocular microscope—either with the scale submerged in water in a atch glass or dry between two glass slides—was preferred to projecon, mountings, or scale impressions. Some scales exhibited so many ominent, false annuli that they were discarded as unreadable; and

Table 1. Fork Lengths of 3- and 4-Year-Old Menhaden Taken from the Waters of the Inner New York Bight During the Period April 23 to May 12, 1948*

Length in half centimeters	Age Class			
	III		IV	
	Male	Female	Male	Female
55	..	..	..	..
56	..	..	..	..
57	..	1	..	..
58	..	..	..	..
59	1	..	..	..
60	4	1	..	..
61	5	1	..	..
62	6	1	..	..
63	12	6	1	2
64	9	11	2	2
65	9	15	4	4
66	5	10	2	11
67	..	3	5	9
68	1	2	2	8
69	..	1	..	4
70	..	..	1	4
71	..	..	..	..
72	..	..	..	1
73	..	..	..	..
74	..	..	..	..
75	..	..	..	..
Total.....	52	52	17	45

* A total of seven 5-year-old fish (two male and five female) were also taken during this period. The data were made proportionate by random subsampling for the analyses of variance in Tables 2 and 3.

the third, fourth, and fifth annuli on the scales of the larger fish were often so close together near the periphery that accurate age diagnosis was difficult. The length-frequency groupings (Table 1 and Figure 2), however, have given us considerable confidence in the results of our readings.

Growth

The size compositions of the menhaden schools, by length-frequencies, during the 1948 and 1949 seasons and for the first part of 1953, are indicated by the accompanying graphs (Figure 2); the growth rates of young-of-the-year by the accompanying photographs (Figure 3).

First runs of fish, prior to 1953, were, upon the basis of scale analyses, composed almost entirely of 3- and 4-year-old menhaden.

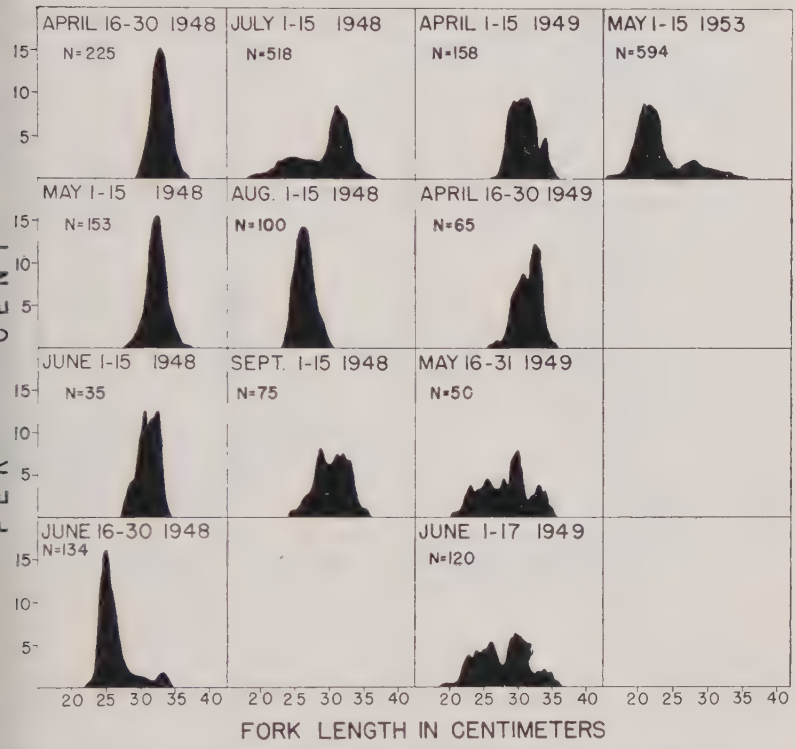

Figure 2. Size composition of menhaden samples from commercial catches in Long Island and New Jersey waters. Data have been smoothed once by threes.

Two-year-old menhaden entered the commercial catches in large numbers some weeks later. We failed to discover any menhaden in its second year of life in any of our samples prior to 1953. In that year, however, numbers of them appeared with 2-year-old fish in the May sample (Figure 2).

Zeros appeared in estuaries, in tidal rivers and creeks, and in mooring basins and canals during June, and apparently remained in these situations until late September or October. Early summer to autumn samples of these zeros are portrayed in Figure 3.

The abundance of these young menhaden is difficult to imagine and, unlike the adult population, they exhibit no aversion to fresh water. They have been found in numbers as far up the Hudson River as Newburgh; in the Peconic River at Riverhead, Long Island; and in the Maurice River at Millville, New Jersey. On the other hand, we

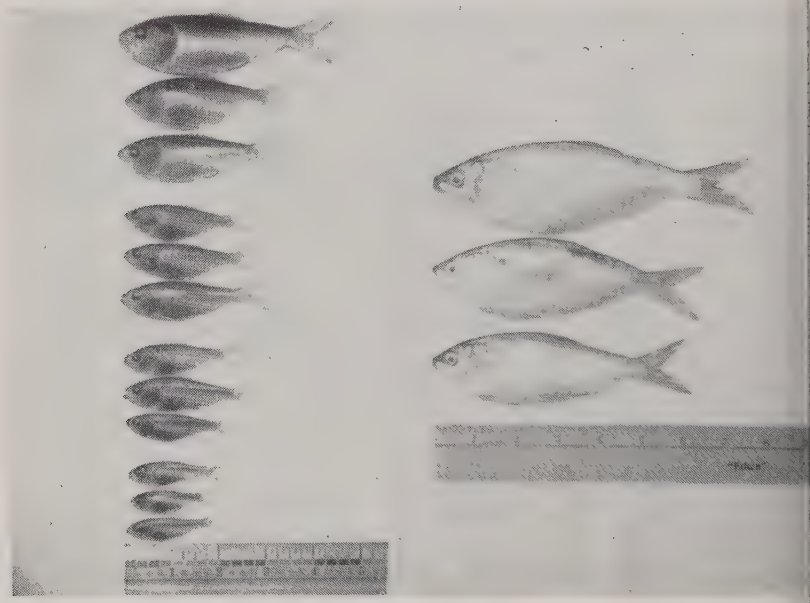

Figure 3. Growth of menhaden during first summer of life.

have failed to find them entering fresh-water lakes, or any evidence of their becoming landlocked. This, of course, is not surprising, since the menhaden is not an anadromous species.

Possible differences between the growth rates of the sexes were studied. The lengths of the 3- and 4-year-old males and females in Table 1 were compared by means of an analysis of variance (Table 2) and the differences were found to be highly significant.

That the difference between the 3-year-old males and females, when considered separately, is also highly significant is shown by the analysis in Table 3.

Fork lengths of menhaden can be converted to total lengths by employing a conversion factor of 1.1163. Scattergood, Trefethen, and Coffin (1951, p. 93) reported the conversion factor from standard to fork length to be 1.0459.

Reliable data on the growth rates of the zeros are difficult to obtain because of the extended spawning season. Perlmutter (1938) reported this season, upon the basis of eggs and post-larvae in plankton tows, to extend from May through October in Long Island waters during that year (1938). The prolonged spawning season is reflected in the size range among the zeros, i.e., while some young-of-the-year

Table 2. Analysis of Variance in Growth Rate for the 166 Menhaden Recorded in Table 1

Source of variation	Degrees of freedom	Sum of squares	Mean square
Total	137	727.30	
Age	1	190.28	190.28
Sex	1	61.33	61.33**
Interactions			
Age—sex	1	0.28	0.28
Within sub-classes	134	475.41	3.55

** Significant at one per cent level.

Table 3. Analysis of Variance in Growth Rate Between Sexes for the 104 3-Year-Old Menhaden Recorded in Table 1

Source of variation	Degrees of freedom	Sum of squares	Mean square
Total	103	437.96	
Sex	1	49.84	49.84**
Error	102	388.12	3.805

** Significant at one per cent level.

may reach a length of 7 inches by mid-October, schools of 2- to 3-inch menhaden can sometimes be found in inshore waters at this same time of year. Whether these late-spawned fish contribute substantially to the annual increment is a moot question; but Perlmutter (1938) reported the peak of the spawning season to occur in May, and, aside from the matter of survival, the factor of numbers must be considered.

The zeros appear to commence emigration from estuarine waters during late September or October, and where they spend their second summer of life during most years is unknown to the authors. Rush (1952) reported the presence of zeros in commercial catches taken near Beaufort, North Carolina, during November and December of 1949 and January of 1950. Five fish of this age class were examined and found to have a mean fork length of 4.5 inches. Those fish showing a single annulus averaged 7.3 inches in length. It is interesting to note in passing that the growth curve reported by Rush (1952), which was based upon 34 fish, is similar to the growth rates found by the authors upon the basis of many times that number of specimens.

SPAWNING

All menhaden 3 years of age or more appear to be adult fish, although the varying degrees of "ripeness" of the gonads at any one

time may again reflect the prolonged spawning season. Most males and at least some of the females, with two annuli on their scales appear to reach adulthood during their third year of life. A few of the 1-year old males in the May, 1953, samples appeared to be adults—or near adults—even though the gonads were very small.

Perlmutter (1938) reported the capture of eggs and larvae of menhaden at 27 of 52 sampling stations in the waters adjacent to Long Island. It is interesting to note that no eggs or larvae were obtained from Great South Bay stations despite the fact that zero- more than an inch in length are usually abundant in most of the tidal creeks, yacht basins, and canals of Great South Bay from July to October.

Mass Mortalities

The annual, heavy mortality of menhaden in the waters adjacent to New York Harbor occurs in late May and June when millions of fish die and litter the beaches (Figure 4). Dying fish, called "spinners" are characterized by a loss of coordinated movements and exopthalmia

Figure 4. Dead menhaden litter Staten Island beach.

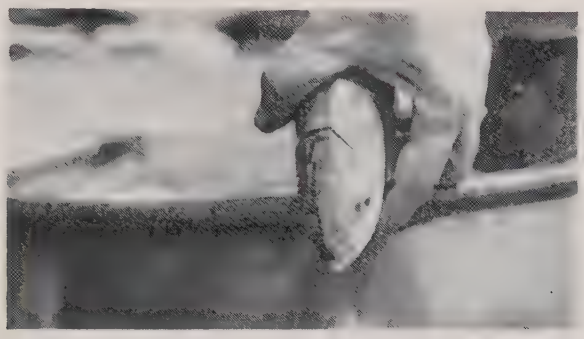

Figure 5. Menhaden with exopthalmia from gas emboli.

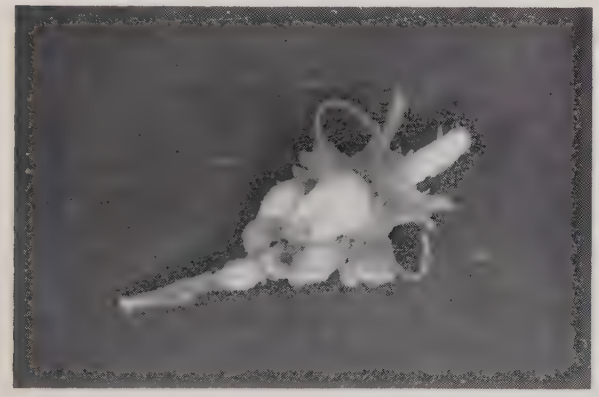

Figure 6. Brain of menhaden showing hemorrhage of the optic lobe.

of one or both eyes (Figure 5). Hemorrhages, caused by gas emboli, were noted in the capillaries of the gills, eyes, and optic lobes of the brain (Figure 6). The culture tests of the scales, and the experimental feeding of stomachs and intestines to cats, yielded negative results.

Whether the gas emboli noted above are a terminal cause of death, or merely represent an associated condition, is a matter of conjecture. We have failed to note the condition, however, in any fish that was not exhibiting signs of distress.

Analyses of the waters in which these annual mortalities occur show two conditions that might be associated with the phenomenon: (1) markedly varying salinities; (2) organic pollution to a degree where shellfishing is prohibited. So far we have failed to find an area where menhaden exhibit this annual mortality, which does not exhibit both of these conditions.

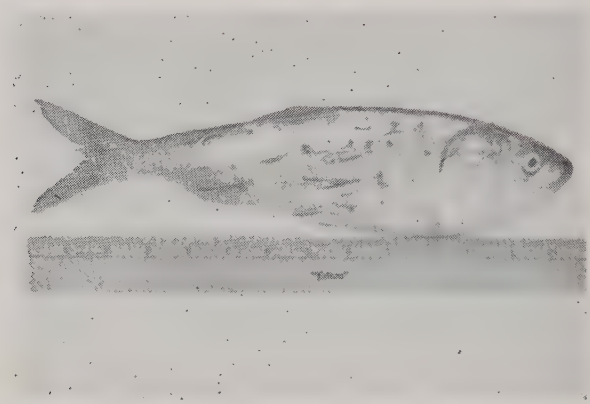

Figure 7. Menhaden heavily infested with parasitic copepods.

The parasites, especially those found on the gills, may contribute to an early demise of fish whose resistance has been considerably reduced by abnormal conditions of the environment such as high temperatures, lowered salinity, or other chemical and physical factors leading to an "imbalance" of the biocenose.

Menhaden along the Atlantic coast of North America are susceptible to the following parasites:[2]

Myxosporidian protozoan	
Chloromyxum clupeidae	(flesh)
Monogenetic trematodes	
Diclodophora sp.	(gills)
Digenetic trematodes	
Hemiurus appendiculatus	(stomach)
Podocotyle atomon	(intestine)
Cryptocotyle lingua	(metacercarial cysts in the skin)
Trypaborhynchid cestodes	
Pterobothrium heteracanthus	(cysts in the viscera)
Rhynchobothrium sp.	(cysts in the viscera)
Copepods (see Figure 7)	
Bomolochus teres	(gills)
Caligus schistonyx	(body surface)

[2] In addition to identifications by the authors, references used in compiling this list included Linton (1901, 1940) and Wilson (1932).

Caligus chelifer	(body surface)
Lernanthropus brevoortiae	(gills)
Lernaeenicus radiatus	(body surface)
Clavellisa spinosa	(gills)

Nematodes

Several unknown species of ascaroids encysted in the mesentery and free in the intestine.

Lernaeenicus radiatus is especially common in menhaden of New Jersey and Long Island waters.

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DEER WEIGHTS AS AN INDEX OF RANGE CONDITIONS ON TW WILDERNESS AREAS IN THE ADIRONDACK REGION[1]

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ABSTRACT

Dressed weights of white-tailed deer from two wilderness areas in t central Adirondacks of New York are reported according to sex and age. Th deer were killed during a fall following a very mild winter when losses due starvation were negligible to nonexistent. These weights are compared wi those of deer from more accessible areas of the Adirondacks during the sam fall, from the Adirondacks during falls following winters when losses due starvation were moderate to heavy, from Vermont range that had bee severely over-browsed but where starvation had not been found, and from th best deer habitat in New York. Based on the weights recorded, deer rang conditions on the two wilderness areas are poorer than those in more accessib parts of the Adirondacks. The evidence indicates that adequacy of the foo supply during the winter is the critical factor.

The weight of deer usually varies with the condition of the rang on which they live. It also increases with age until a deer reaches i prime. If both weight and age are known for a representative samp of the population in an area an index of its range quality is afforde

While information of this kind had been recorded from time t time during previous years, an opportunity to obtain additional, esp cially pertinent, data came in the fall of 1954. A special open seaso for antlerless deer, coincident with the season for antlered deer, w declared on two wilderness areas in the Adirondacks which were co sidered to be overstocked. On these areas, the holder of a speci license for taking antlerless deer was entitled to take an antlered de also.[2] Thus, both sexes and all ages would be represented in the tak

The two areas, one known as the South Branch Moose Rive West Canada Creek Tract and the other as the Oswegatchie Rive Beaver River Flow Tract, have been described by Cheatum (1954 Their boundaries were established at least 3 miles from any tow county, or state highway. Some characteristics of the general regi and its deer population (Cheatum and Severinghaus, 1950; Severin haus, 1947; Severinghaus *et al.*, 1950) and of the Moose River Plai (Smith and Severinghaus, 1954) have been published.

In order to administer the special regulations required by law c

[1] A contribution of Federal Aid in Fish and Wildlife Restoration Proje W-28-R.

[2] Possession of a regular big game license was required to qualify for a speci license.

hese two tracts, checking stations were operated at the major access oints. In some cases, these were situated, for convenience, at some istance from the actual boundary lines. Successful hunters were re-uired to bring their deer out through these stations. This provided an xcellent opportunity to obtain data on the deer taken, not only by hose hunting within the two designated tracts, but also by those hunt-ng surrounding territory who found it desirable to pass a station.

PROCEDURE

A total of 18 checking stations was operated. A game technician as assigned to each for the first 21 days of the 37-day season (October 5 to November 30). During the last 16 days the stations were operated y local residents or non-technical personnel.

For the periods when technicians were present as many as possible f the deer brought to the stations were examined and their weight nd age recorded. Weights were taken to the nearest pound. Because ie animals had been dressed out, the figures represent the entire arcass minus the entrails including the heart and lungs. Age was dged by the method of Severinghaus (1949).

FINDINGS

Weight and age data were obtained for a total of 1,444 deer from ie two wilderness areas, and, in addition, 168 bucks from surrounding rritory were checked. A summary of the former is given in Table 1.

ABLE 1. Summary of Deer Taken From the Two Wilderness Areas in the Adirondacks in 1954 and for Which Weight and Age Data Were Obtained

Sex and age	Number	Per cent
ale		
Antlered	375	26.0
Antlerless		
Fawn	173	12.0
Yearling	62	4.3
2½ years	3	0.2
Sub-total	613	42.5
male		
Fawn	173	12.0
Adult	658	45.5
Sub-total	831	57.5
tal	1,444	100.0

Of interest are the yearling and 2½-year-old males in the antlerles group.[3]

The weight records for the specimens from the wilderness area are given, according to sex and age, in Table 2. The averages show a

Table 2. Dressed Weights of Deer Taken from Two Wilderness Areas in the Adirondacks in 1954

Age	Male				Female			
	Number of specimens	Weight			Number of specimens	Weight		
		Minimum	Maximum	Average		Minimum	Maximum	Average
Fawns								
Under 5 months	101	24.0	68.0	52.4	106	26.0	68.0	49.
5 to 6 months	56	40.0	70.0	54.5	52	40.0	74.0	53.
Over 6 months	16	42.0	75.0	57.5	15	46.0	88.0	59.
Total fawns	173	24.0	75.0	53.6	173	26.0	88.0	51.
Adults								
Yearlings								
1 year 5 months or less	90	52.0	165.0*	82.5	79	50.0	114.0	77.
1 year 6 months	58	58.0	124.0	85.2	39	63.0	110.0	76.
1 year 7 months or more	18	70.0	113.0	84.7	26	60.0	110.0	86.
Sub-total	166	52.0	165.0	83.6	144	50.0	114.0	79.
Other adults								
2½ years	94	70.0	168.0	115.5	129	60.0	122.0	90.
3½ years	77	80.0	205.0	135.8	172	64.0	134.0	93.
4½ years	53	108.0	210.0	148.4	66	72.0	170.0	95.
5½ years	25	100.0	187.0	144.2	45	62.0	140.0	94.
6½ years	15	95.0	192.0	148.5	30	77.0	122.0	94.
7½ years	8	125.0	180.0	148.6	29	69.0	125.0	93.
8½ to 9½ years	1	158.0	158.0	158.0	30	70.0	120.0	91.
10½ years or more	1	125.0	125.0	125.0	13	85.0	110.0	95.
Sub-total	274	70.0	210.0	130.4	514	60.0	170.0	93.
Total adults	440	52.0	210.0	114.4	658	50.0	170.0	90.

* Among the yearling males only one specimen weighed more than 124 pounds

progressive increase up to the age of 4½ years for both sexes, but after that they indicate a slight decline.

[3] Under New York law, antlerless deer are those having no antlers or antlers less than 3 inches in length.

Table 3. Dressed Weights of Adult Bucks Taken Outside the Two Wilderness Areas in the Adirondacks in 1954

Age	Number of Specimens	Weight		
		Minimum	Maximum	Average
Yearlings				
1 year 5 months or less	25	70.0	124.0	94.6
1 year 6 months	11	80.0	106.0	95.5
1 year 7 months or more	6	80.0	124.0	98.8
Sub-total	42	70.0	124.0	95.5
Other adults				
2½ years	46	85.0	200.0	125.2
3½ years	39	105.0	182.0	142.6
4½ years	23	130.0	198.0	166.8
5½ years	10	115.0	170.0	150.2
6½ years	6	145.0	208.0	164.2
7½ years	1	158.0	158.0	158.0
8½ years to 9½ years	1	134.0	134.0	134.0
10½ years or more	...	.....	.....	.....
Sub-total	126	85.0	208.0	142.4
Total	168	70.0	208.0	130.6

The weight records for antlered bucks from outside the wilderness areas are given in Table 3. They also show a progressive increase in average weight up to the age of 4½ years and a slight decline after that. In every age class except the two oldest, these bucks averaged heavier than those from the interior tracts.

DISCUSSION

It seems evident that the bucks inhabiting the territory outside the wilderness areas averaged heavier than those within these tracts. Presumably a similar relationship existed among the does as well. This would seem to reflect poorer range conditions in the interior where hunting has been less intensive than in the more accessible localities.

Another factor to be considered in this analysis is the influence of winter weather. Severe conditions at this season, especially on overstocked and overbrowsed range, result in widespread malnutrition and often considerable mortality among deer. It has been recognized for a long time that deer which suffer serious loss of weight and almost die of starvation during the winter never attain the weight status of deer which secure adequate nutrition throughout the year (Gerstell, 1938). In spite of the fact that no shortage of summer food has been recog-

nized in New York, fall weights of deer are lower following severe winters than they otherwise would have been.

For several years prior to the fall of 1954 the winters had been very mild and losses due to starvation were negligible or nonexistent. Thus, for Adirondack range conditions, deer weights should have been relatively high. In contrast, the winters preceding the falls from 1938 to 1943 were moderately severe and accompanied by considerable mortality. Data recorded at that time for deer taken in the central Adirondacks showed average weights to have been markedly lower than those for the wilderness areas in 1954 (Table 4). And many of the 1939-43 records were from territory more nearly comparable to that surrounding the wilderness tracts. It may be inferred, then, that a similar series of specimens taken from the interior range during those years would have weighed correspondingly less.

Table 4. Comparison of Dressed Weights of Deer from the Adirondack and Southern Tier Regions of New York

Sex	Region and period	Fawns		Adults	
		Number of specimens	Average weight	Number of specimens	Average weight
Male	Adirondack, 1939-43*	22	48.8	81	105.9
	Adirondack, 1954§	173	53.6	440	114.4
	Southern Tier, 1939-43	71	64.9	62	125.5
Female	Adirondack, 1939-43*	45	46.3	226	85.3
	Adirondack, 1954§	173	51.3	658	90.0
	Southern Tier, 1939-43	76	57.7	149	103.4

* Represents a series of falls following moderately severe winters during which moderate mortality from starvation occurred.

§ Represents a fall following a very mild winter during which mortality from starvation was negligible or nonexistent.

A further comparison may be made with records from range of known high quality. In New York some of the best deer habitat is that of the Southern Tier counties (the territory bordering Pennsylvania from Broome County west). Data for specimens from this region were also obtained during the period from 1939 to 1943. There, however, the winter climate is much less severe than in the Adirondacks and, at that time, malnutrition was negligible. The deer weights recorded averaged substantially higher than those for the Adirondacks taken during the same period as well as those taken in 1954. This comparison is also shown in Table 4.

Table 5. Dressed Weights of Adult Bucks From the Two Wilderness Areas in the Adirondacks (1954) and From Vermont (1946 to 1950)

Age in years	Average weight		Number of specimens	
	Adirondacks	Vermont	Adirondacks	Vermont
1½	86.0	106.4	208	1,608
2½	118.7	132.6	140	959
3½	138.1	156.5	116	449
4½	154.0	172.4	76	196
5½	145.9	176.2	35	91
6½	153.0	181.4	21	25
7½	149.6	175.8	9	12
8½	146.0	172.5	2	4
9½	.....	175.0	...	3
10½	125.0	115.0	1	1

Moreover, the degree of difference probably was considerably greater than these figures indicate because the adults from the southern range were predominantly yearlings and 2½-year-olds (Maguire and Severinghaus, 1954), whereas a large proportion of those from the wilderness tracts were older deer (Table 2). For example, among the adult males from the latter, the average weight of the yearlings and 2½-year-olds alone was only 95.2 pounds. This further accentuates the significance of the lighter average weight of the deer from this interior Adirondack range.

Still another, and perhaps even better, comparison may be made with records of bucks taken in Vermont from range that was severely overbrowsed but on which starvation losses had not been found to be serious (Table 5).[4] Heavy weight loss had been chronic among deer on this range. Yet, even under these conditions, their fall weights, age for age, averaged about 24 pounds more than those for the bucks taken on the two wilderness areas in New York. Nevertheless, they were less than for bucks from southern New York.

CONCLUSIONS

Using the weights recorded as an index, it may be concluded that deer range conditions on the two wilderness areas sampled are poorer than those in more accessible, and consequently more heavily hunted, territory. This corroborates other data that have been gathered on this problem. The evidence indicates that adequacy of the food supply during the winter is the critical factor.

[4] Data supplied by Roger Seamans, Vermont Fish and Game Service.

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THE EFFECT OF SIZE AT PLANTING ON SURVIVAL AND TIME OF DOWNSTREAM MIGRATION OF ATLANTIC SALMON IN A TRIBUTARY OF LAKE GEORGE[1]

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ABSTRACT

Annual planting of yearling Atlantic salmon in tributaries of Lake George during April and May since 1948 has materially increased the angling resource of "landlocked salmon". "Immediate" migration from stream to lake (during year of planting) is desirable because (1) the rapid period of lake growth commences sooner and (2) heavier densities of salmon can be supported temporarily in a stream during the spring period of high flow. "Delayed" migration (during year after planting) affords a useful means for utilizing the permanent carrying capacities of streams. Experiments to test the effect of size at planting on the time of downstream migration were carried on in 1953 and 1954 in Huddle Brook, a tributary of Lake George.

A trap weir was constructed early in May, 1953, and small salmon yearlings, averaging 3½ inches in length, were planted. Since salmon of this same average size had been planted in 1952, the first season of trapping in 1953 afforded a basis for comparing "immediate" and "delayed" migration. Trapping was discontinued December 22 and resumed March 31, 1954. On April 22 a plant of larger salmon, averaging 5½ inches in length, was made using adipose fin-clip marks to distinguish them from overwintering fish. Trapping was terminated June 20.

Data resulting from the total of 830 salmon trapped during the two years indicated downstream migration to be confined to April, May, and June (an October catch of two parr being considered a purely local movement). Some degree of transformation from the parr to the smolt stage was clearly demonstrated as a factor, but there was a wide variation in the degree of this development. The planting of 5½-inch yearlings (all in or near the smolt stage at planting in 1954) gave 27.1 per cent "immediate" migration, while the planting of 3½-inch yearlings (approximately 95 per cent in the parr stage at planting in 1953) gave only 0.6 per cent "immediate" migration. The two plantings of 3½-inch yearlings gave closely-comparable figures for "delayed" migration, the 1953 trapping of the 1952 plant (only partially complete due to some migration before initial operation of trap) giving a return of 3.9 per cent and the 1954 trapping of the 1953 plant giving a return of 3.1 per cent.

The study suggests the desirability of stocking Lake George tributaries with small yearling salmon up to their estimated capacity to carry and grow such fish until the following spring and of adding to such number sufficient large yearlings to utilize temporarily increased carrying capacities during the spring months and to migrate before the onset of summer low-water conditions. Proper adjustment of sizes and numbers to conditions of individual streams would give a "self-thinning" plant.

The management of Atlantic salmon *(Salmo salar)* is complicated by the naturally migratory behavior of the species. Many published

[1] A study made possible through cooperation of the Warren County Conservation Council. Funds for construction and operation of a trap weir were made available from a conservation project fund appropriated by the Warren County Board of Supervisors. Permission to build this structure on privately-owned lands was given by Messrs. Earl Woodward and Walter Dombak.

observations indicate that salmon in the parr stage naturally inhab streams while salmon in the smolt stage inhabit the ocean or larg lakes.

In the course of a study for the purpose of developing practica methods for increasing landlocked salmon in New York lakes man planting methods have been tried. The planting of parr directly i lakes has not given good results generally, perhaps due in part to th predominance of competitive and predatory fish. The rearing c salmon to the smolt stage and the direct planting in lakes of thes larger fish has given encouraging results, but so far the low output c suitably-large salmon has precluded the use of direct planting in ver large lakes. The planting of salmon in tributary streams has so fa been the most successful method, especially the planting of yearling during April and May.

Upper Huddle Brook, just below Trout Lake, during spring period of heav flow.

In New York, the acreage of streams suitable to carry salmo until they will naturally migrate into a lake is usually very limited i relation to acreage of the lake. Moreover, most streams have tempo rarily greater carrying capacities during the spring period of heav run-off. In order to utilize the full carrying capacities of streams o various types, it is necessary to be able to predict the time of migratio of salmon and this is affected by size, time of planting, and growth rate. For example, streams with good temporary carrying capacity bu

poor permanent carrying capacity can be effectively used only if salmon migrate soon after planting. The better types of streams can support some salmon on a year-round basis and this carrying capacity should be utilized. The maximum use of such streams would require stocking with adjusted numbers of salmon of various sizes so as to produce a "self-thinning" plant through migration of the larger salmon before summer low-water conditions occur.

Lake George is a large body of water (computed area 28,416 acres) which has proven suitable for survival and growth of Atlantic salmon. Since 1948, tributaries have been stocked with yearling salmon of Canadian sea-run parentage and ranging from approximately 2 to 6 inches in length. These fish have provided most of the so-called landlocked salmon taken by anglers in this lake. By use of fin-clipped salmon in 1950 (Greeley, 1955), Huddle Brook, a tributary of this lake, has been shown to have given some survivals.

PROCEDURE

This stream was selected for experimental plantings of Atlantic salmon yearlings of 3½- and 5½-inch average size and operation of a trap weir to study survival and downstream migration in 1953 and 1954. The fish were reared at the Cambridge Fish Hatchery (Washington County).

Construction and Operation of Trap

A specially-designed horizontal screen and live-box trap weir (Figure 1) similar to the "Wolf trap" (Wolf, 1950) was constructed on lower Huddle Brook, just above its mouth, at a point where a low, concrete dam (built to protect the crossing of a water main) could be utilized to provide a drop. There was insufficient fall to give the 21.7 inches which Wolf recommends as a minimum for water falling from the crest of a dam to a horizontal screen. Even by adding a log to raise the crest of the dam, a drop of only 14 inches, approximately, was possible but this worked adequately with a screen of ⅛-inch mesh hardware cloth. The wooden live box was protected against overflow by using a vertical screen of ¼-inch hardware cloth.

Following preliminary tests on May 5, 1953, regular operation of the trap weir was started May 8 with daily records being made. This schedule was continued until December 22. Due to ice damage the screen was then removed and was not put back until March 31, 1954. Since no fish were taken in November and December, or between

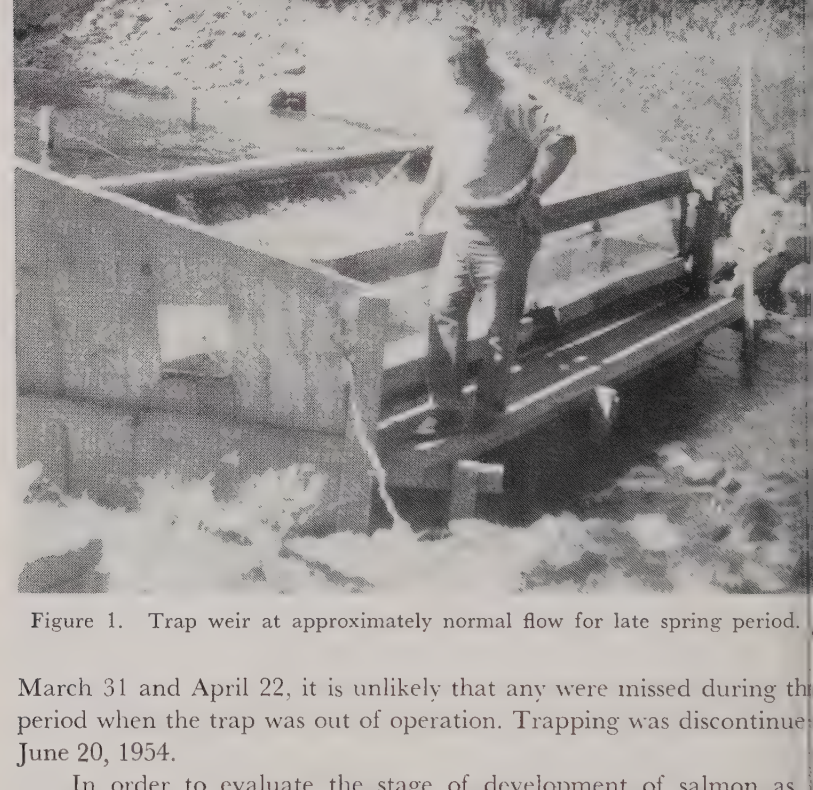


Figure 1. Trap weir at approximately normal flow for late spring period.

March 31 and April 22, it is unlikely that any were missed during th period when the trap was out of operation. Trapping was discontinue June 20, 1954.

In order to evaluate the stage of development of salmon as factor in migration, the trapped fish were separated into parr, smol and intermediate types. This classification is only approximate. Ind viduals showing conspicuous parr marks and without conspicuou silvering of the scales were classed as parr. Fish with conspicuou silvery coloration sufficient to obscure the parr marks were classed a smolts. There were many individuals in which this process of develop ment was intermediate.

Temperature and approximate height of water were recorded Incidental notes on other species of fish taken were recorded (no reported here). All fish trapped were liberated below the weir t prevent recapture.

Salmon Planting Experiments

On April 22, 1952, approximately a year before construction o the weir, 2,500 yearling Atlantic salmon averaging 3½ inches an

weighing 28.5 pounds had been planted. These fish entered into the study in 1953 in that survivors migrating during that spring were trapped in considerable numbers. Since some movement of these fish was recorded immediately upon putting the weir in operation on May 5, 1953, it may be assumed that an unknown percentage, i.e., those moving downstream in the spring prior to May 5, escaped capture.

The 1953 plant, made May 8, consisted of 5,000 yearling Atlantic salmon averaging 3½ inches. This lot of fish, weighing 44.0 pounds, was graded carefully and consisted of parr predominantly. Not over 5 per cent of the fish were in or approaching the silvery coloration characteristic of the smolt stage. A few individuals were 4 inches or slightly more. By operating the weir from the planting date (May 8) to December, 1953, the migration of this lot was studied. As already mentioned operation was discontinued between December 22, 1953 and March 31, 1954, but there is reason to conclude that no migration occurred between these dates as will be discussed later.

The 1954 plant, made April 22, consisted of 2,010 yearling Atlantic salmon averaging 5½ inches. This lot of fish, weighing 104.0 pounds, was hand-selected for size and for smolt development. All individuals were in or approaching silvery coloration and typical parr were culled out. The lot was marked by clipping the adipose fin. Migration was studied between April 22 and June 20, when operation of the weir was discontinued.

Criteria for Determining Downstream Movement

Since the purpose of trapping salmon was to study the normal downstream migration rather than mere local movement, it was necessary to establish a method of differentiation between these two types of fish movement. This can be done on the basis of the proportion of the test salmon trapped and the stage of development of individual fish. The movement of salmon parr was very minor during all periods the weir was in operation. In this respect it resembled the movement of other stream fish present in Huddle Brook, including brown trout. In contrast to this, the movement of salmon smolts and individuals approaching the smolt stage was a mass movement of much greater magnitude.

RESULTS

The data and observations recorded during the study are presented under several topics.

Time of Downstream Movement of Salmon

Based on operation of the weir in 1953 and 1954, the mass down stream migration of salmon occurred in the spring months, taperin off in June. In 1953, the only year when the weir was operated in Jul and August, not a salmon was trapped in these months. The fa months during the same year yielded a total catch of only two pa (both on October 30) and this was considered as a purely local move ment. November and December trapping was negative and presumabl no migration would have been recorded in the other winter months the trap had been operated. Between March 31 and April 22, 195 there were no salmon trapped.

Effect of Size and Smolt Development on Migration

Atlantic salmon are variable in the size at which a change fro parr toward smolt characteristics becomes discernable. At the Cam bridge Hatchery occasional fish as small as 4 inches show the silve color and darkening of fins which indicate smolt development whil still other individuals as large as 6 inches remain in typical parr colo ation. Despite such variation, it is clear that large size and smol development are closely linked.

Examination of salmon trapped in the weir indicated a somewha confusing amount of variation in regard to the degree of smolt devel opment. As already mentioned a few typical parr were trapped i what may have been purely local movement. Some typical smolt bright silvery with the red spots obscured, were taken. The majorit of salmon taken in mass downstream movements were in intermediat stages but showed, by reason of silvery coloration, some degree o smolt development.

Comparison of the data for "immediate" migration, i.e., durin the spring in which stocked, indicated a very great difference betwee the 3½-inch yearlings (predominantly parr) used in 1953 and th 5½-inch yearlings (smolts or "transitional" smolts) used in 1954. I 1953, between the planting date of May 8 and June 22, the trap too only 31 salmon attributed to the 3½-inch group, or 0.6 per cent o the total 5,000 planted. In 1954, between the planting date of April 2 and June 1, the trap took 545 salmon of the 5½-inch group, or 27. per cent of the total 2,010 planted. The data are given in Table 1.

Comparison of sizes at trapping, for fish taken during the sam season as planted, indicated the 1953 salmon averaged 4.4 inche (range 2.0 to 5.3 inches) while the 1954 fish averaged 5.5 inche (range 4.5 to 7.5 inches).

Table 1. Relative Recovery of Yearling Atlantic Salmon Planted in Huddle Brook as Indicative of Immediate and of Delayed Migration

Item	Date of plant		
	April 22, 1952	May 8, 1953	April 22, 1954
Size	3½-inch	3½-inch	5½-inch
Number planted	2,500	5,000	2,010
Immediate migration*			
Number	xxx	31	545
Per cent	xxx	0.6	27.1
Delayed migration§			
Number	97	155	xxx
Per cent	3.9	3.1	xxx

* During same spring as that of planting.
§ During spring following that of planting.

Migration of the 1953 plant was followed during the spring of 1954 when 155 were trapped, or 3.1 per cent of the total 5,000 planted. The average size was 6.2 inches (range 5.0 to 8.0 inches). In 1953 the incomplete spring trapping between May 5 and June 22 of survivors from the 1952 plant of 3½-inch salmon gave a total of 97, or 3.9 per cent of the total 2,500 planted, and these fish averaged 6.9 inches (range 5.0 to 9.5 inches).

Environmental Conditions Affecting Survival and Migration

Water temperatures, taken daily during operation of the weir, and notes as to stage of water were considered desirable for study. In 1953 the water temperature of Huddle Brook during the period May 8 to June 22 when migration was taking place ranged from 58° to 68° F. In 1954 temperatures between March 31 and April 28, when first recorded migration of overwintering salmon (1953 plant) occurred, ranged from 40° to 55° F. However, the migration of the 1954 group began immediately upon planting April 22, at which date the stream temperature was 54° F. and this migration continued until June 1. The relationship of water temperature to the number of salmon taken as the season progressed is shown in Table 2.

In both 1953 and 1954 the spring migration occurred during conditions when stream flow was well above minimum low. Extremely high water on several occasions showed no depressing effect on migration. There appeared to be no close correlation between stage of water

Table 2. Relation of Water Temperatures in Huddle Brook to Number of Salmon Trapped During Spring Migration Period in 1953 and 1954

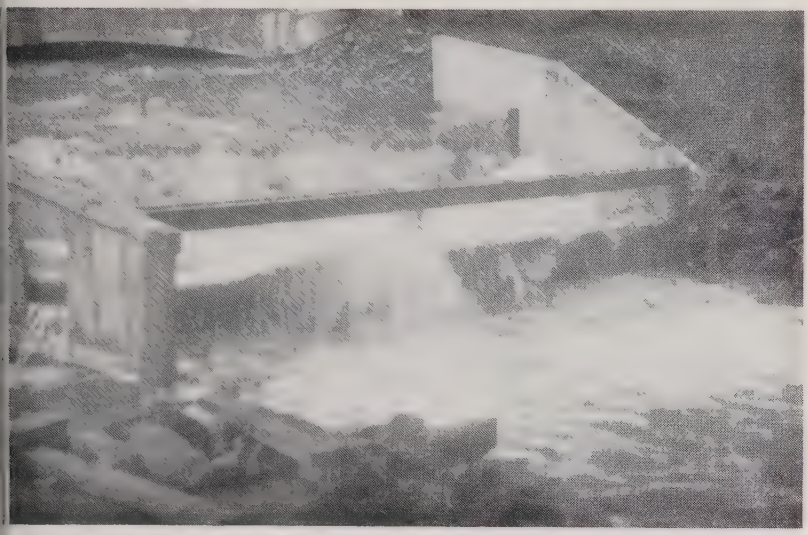
Item	April		May					June		
	22-23	24-30	1-7	8-14	15-21	22-28	29-31	1-7	8-15	16-22
1953										
Temperature range*	xxx	xxx	xxx	58-64	59-62	54-60	54-60	53-64	56-65	56-68
Number salmon trapped										
Of those planted in 1952 at 3½ inches	xxx	xxx	xxx	60	24	6	1	1	3	2
Of those planted in 1953 at 3½ inches	xxx	xxx	xxx	12	8	7	1	3	0	0

Item										
1954										
Temperature range*	54-54	53-58	52-60	51-53	54-56	57-60	61-64	65-67	68-70	71-74
Number salmon trapped										
Of those planted in 1953 at 3½ inches	0	36	82	30	2	3	2	0	0	0
Of those planted in 1954 at 5½ inches	28	432	47	30	3	2	0	3	0	0

* In degrees Fahrenheit.

and amount of migration. Movement of salmon ended more abruptly in 1954 than in 1953 with the latest trapping record being June 1 in 1954 as against June 22 in 1953. In both years the stream flow in June was less than in May.

A number of supplementary observations made at or above the trap have a bearing upon the interpretation of results and will be mentioned briefly. Several observations subsequent to planting of the 3½-inch yearling salmon on May 8, 1953, indicated that these fish became established in large numbers in Huddle Brook. Within 2 weeks after planting, red spots were visible on sample specimens, and natural food including mayfly nymphs was found in stomachs. Scales indicated a more rapid growth (based on greater width of circuli) than was made under hatchery conditions. Stomachs of 5½-inch yearling salmon planted April 22, 1954, contained angleworms and mayfly nymphs, and scales indicated continuation of growth after planting. It is not considered likely that the trapping of salmon was materially increased by



Trap weir at approximate flood stage in late afternoon on May 8, 1953, a few hours after salmon were planted.

the dropping downstream of weak or sick fish. In general the physical condition of salmon which had wintered over in Huddle Brook was excellent and even better than that of recently-planted fish as judged by general appearance. No weights of individual salmon were taken. On many occasions large numbers of earthworms and mayfly nymphs were observed in the trap during periods of salmon migration.

Several field observations in Huddle Brook during very low water in June disclosed salmon parr of the May 8, 1953, plant hiding under stones in pools. Both the number of suitable feeding positions and the amount of available food as compared to conditions in late spring were greatly decreased.

An important question bearing upon interpretation of the relative success of stocking small or large salmon is whether those fish which migrate into a lake soon after stocking would survive as well as those which have spent approximately a year in a stream subsequent to planting. This question was not intensively studied. However, five specimens with adipose fin-clip marks, representing survivors of the 1954 plant, were taken in Lake George during the annual netting for spawners. These salmon had grown well, their total length in November 1954 being as follows: 15.4, 13.8, 13.1, 13.1, and 11.5 inches. This observation indicates that some, at least, of the 5½-inch salmon which

moved out of Huddle Brook soon after being planted on April 2 1954, were able to grow well during their first season in this lake.

Standardization and Sources of Error

As bearing upon interpretation of results, it should be mentione that there are many variables which could not be overcome throug standardization, even though effort was made to remove as man sources of error as possible. Experimentation in a wild environmen involving comparison of two years' observations, is subject to man uncontrollable variables.

Huddle Brook represents a somewhat complex environment i that it derives its major source of water from Trout Lake (250 acres has a small impoundment in its course, and receives considerab spring seepage. Effort was made to scatter the planted salmon, in bot 1953 and 1954, over approximately 4 miles of stream and the lowe part of one tributary by use of numerous access points. The fis reached the stream in excellent condition. A heavy rain, which raise the stream to flood stage on the evening of May 8, 1954, soon afte completion of the planting on that date, seemed to have little effec in inducing immediate migration of the planted 3½-inch salmon. I both years planted salmon were stocked under fish population condi tions which included some survival of salmon from a previous yea

The interval between the two planting dates (May 8 and Apr 22) was somewhat greater than would have been desirable.

The identification of salmon as to source of plant was considere reliable with, however, opportunity for minor error. The unmarke salmon planted in 1953 were 4 inches or less at planting and wer readily distinguishable from overwintering salmon in the stream whic were 5 inches or more. In addition to size, the coloration of hatcher salmon was different, the recently-planted fish having no red spot However, the coloration differences are temporary and by June it possible that some misidentifications occurred in 1953 among th smaller individuals. Fortunately, any errors from this source woul have been minor since few salmon were taken in June. In 1954 th use of marked salmon precluded any misidentification of this plan

In both 1953 and 1954 it is possible that a small percentage o salmon attributed to survival from immediately previous years ma have represented survival from a former year. As to this point, how ever, age determination of a number of samples has shown a rapi growth rate in Huddle Brook, which is a comparatively warm stream

nd no salmon remaining in the stream 2 years after planting as earlings have been found there.

DISCUSSION AND CONCLUSIONS

Mass downstream movement of planted Atlantic salmon occurred n late April and May, and to a lesser extent during June.

Yearlings of 3½-inch average size, predominantly in the parr tage, showed little tendency to migrate during the same spring when lanted. Yearlings of 5½-inch average size, predominantly smolts or artially transformed to this stage, showed a strong tendency to nigrate during the same spring when planted. Direct comparison of ne degree of migration for the two lots (0.6 per cent and 27.1 per ent, respectively) gave a ratio of 1:45. While these figures are not losely comparable, due to variables in the conditions of the experiment as already mentioned, the magnitude of the ratio indicates that here is a great difference in the amount of immediate migration to be xpected from 3½-inch salmon as against 5½-inch salmon.

Planted yearling salmon of 5½-inch average size began migration n considerable numbers immediately after planting on April 22, 1954, hile salmon which had wintered in the stream, all or mostly originating from the 1953 plant, did not begin migrating until April 28, 1954. he average length of the latter migrants was greater, 6.2 inches. This bservation tends to indicate that the degree of migration is not irectly proportionate to the size of the fish. The overwintering salmon ere in various stages of smolt development at the time of migration, ut, on the average, less far along than the hatchery salmon which resumably began heavy feeding earlier in the spring as compared ith those wintering in Huddle Brook. It is concluded that a period f some days at good feeding temperatures is necessary to precipitate nigration of salmon wintering in the stream.

The behavior of migrants resulting from salmon wintering in the ream was closely comparable as indicated by the 1953 and 1954 apping records for average length, length range, and physical condition. It was evident that many salmon migrated before attainment f the full characteristics of typical smolts.

The spring downstream migration took place during periods of ater flow well above summer low and at temperatures from 54° to 3° F. Data from samples of scales and stomachs, and from observaons of food organisms captured in the trap, support the interpretaon that salmon migrated when they were actively feeding on an undance of food and were growing rapidly.

Due to summer low-water conditions the carrying capacity o Huddle Brook for planted salmon is greatly decreased compared with that during the spring. Yearlings of 3½ inches, or smaller, appear to be suitable for stocking in limited numbers with the expectation of a year's residence in the stream and migration during the following spring. Yearlings of 5½ inches or possibly somewhat smaller, appear to be suitable for stocking in greater density with the expectation of migration soon after planting. Proper adjustment of sizes and number in relation to the temporary and permanent carrying capacities of steams is suggested as a desirable objective in stocking Atlantic salmon yearlings.

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EXPERIMENTAL CONTROL OF WATER CHESTNUT *(TRAPA NATANS)* IN NEW YORK STATE[1]

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ABSTRACT

In about 70 years the introduced water chestnut or caltrop has become a noxious water weed over more than 2,500 acres of fresh water in the Mohawk-Hudson-Barge Canal waterway. More recently it has spread to Lakes Keuka and Champlain. Attempts to control water chestnut by underwater mowing failed for lack of complete coverage each season. Spraying with dangerously volatile formulations of 2,4-D had to be halted because of claims of crop damage.

Various types of herbicides, mostly nonvolatile, were tested by applications from pack sprayers and boat-mounted power sprayers. Contact type herbicides, such as ammonium sulfamate and pentachlorophenol, were ineffective. Tests showed that an application of the amine salts of 2,4-D at a rate of 8 pounds acid equivalent per acre in 50 gallons of total solution per acre, with either fuel oil or water as a diluent, would cause a satisfactory kill of water chestnut. Isolated infestations were reduced from dense mats to as few as one plant per year in a period of 3 to 4 years, when seed suppression was complete each season. Application of herbicide by means of helicopters, to get complete coverage of all water chestnut areas each year, is considered a promising approach to the problem.

This study was conducted to find feasible methods of controlling or eradicating a troublesome aquatic weed, the water chestnut, and to settle certain life history questions bearing on this problem. The water chestnut or water caltrop *(Trapa natans)* is an annual aquatic plant native to fresh-water streams, lakes, and ponds of the temperate areas of southern Europe and Asia. Fossil remains of various species of *Trapa* have been found in deposits ranging back to Tertiary times over a much greater area in Europe and Asia and even in Alaska and Saskatchewan (Hegi, 1926; Brown and Houldsworth, 1939). Utilization of water chestnut and related species for food led to deliberate introductions into northern Europe, and, in the last century, to the United States.

The water chestnut was introduced into New York State at Collins (or Sanders) Lake near Scotia, about 1884 (Wibbe, 1886). By 1920 it had spread to the nearby Mohawk River, where in 1935 it occupied about a thousand acres (Winne, 1935). By 1944 it had been found in the Hudson River; by 1952 it occupied an estimated 2,500 acres in the Mohawk and Hudson Rivers and was known to have

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[1] A contribution of Federal Aid in Fish and Wildlife Restoration Projects W-31-D and W-54-R.

spread to Lake Champlain and as far west as Keuka Lake. Elsewher in the United States the water chestnut became established in easter Massachusetts and in the Potomac River near Washington, D. C (Winne, 1935).

Water chestnut survives in wet mud, but grows best in wate depths from several inches to 5 or 6 feet where the water has a hig organic content and where there is a rich mud bottom. In spring th black seeds, which bear four retrorsely barbed spines, germinate an send toward the surface a cordlike, pliant stem, with numerous nod from which are produced both roots and modified rootlike leaves. A the surface is produced a rosette of rhombic, coarsely serrate, leather leaves which are bright glossy green above and pubescent, yellow green below. Each leaf petiole is modified into a spongy, bladder shaped float which helps to support the leaf at the surface of th water.

In the latitude of the Mohawk River, the small white flowe appear about June 25, and continue to appear until September. B late July fruits are well formed, so that by early August they begin t break off and sink to the bottom, where they lie dormant until th following spring, or until conditions are right for germination.

In well-established stands the rosettes are so dense that they ar crowded out of the water, so that the more desirable aquatic an emergent plants are choked out, and so that swimming, boating, an fishing are no longer possible.

Utilization for food has been practically nil because the wate chestnut has grown best in waters polluted by raw sewage, and becaus economic standards in the U. S. have not encouraged its use.

Winne (1935) studied the germination of water chestnut seed and experimentally cut and removed various parts of the plants t determine possible methods of control. He suggested that control coul be effected by suppressing seed formation through cutting and remov ing the rosettes. He tested foliar applications of solutions of ammoniu thiocyanate and sodium chlorate as herbicides, and found that th floating leaves were killed but that the submerged apical meristem were uninjured, so that new leaves soon appeared.

Benson (1941) tried trichlorinated benzene compounds as herbi cides, but found that, while water chestnut plants were killed, th solutions were harmful to fish.

In 1946 the New York State Conservation Department undertoo large scale control operations, using (1) hand-pulling operations i small, isolated infestations, (2) underwater mowers on self-propelle

ense mat of water chestnut in Mohawk River at Crescent on July 23, 1952.

arges operated by the U. S. Army Engineers, and (3) herbicidal prays of the isopropyl ester of 2,4-D in fuel oil. The last were applied surface-operated power sprayers, from a fixed-wing airplane, and om a helicopter. After the 1948 season, as a consequence of claims r crop damage following aerial spraying, operations were restricted the underwater mowers, hand pulling, and a small amount of praying from boats, until safe methods of control or eradication could evolved.

PROCEDURE

The problem was attacked from two viewpoints, an examination the reproductive cycle of water chestnut for any weak points, and evaluation of available control measures.

Life History Observations

The failure of the control operations to halt the water chestnut festations, up to the spring of 1950, led to observations on certain nases of the plant's life history to determine, if possible, the reasons r the apparent lack of success.

Source of Annual Growth

Although the water chestnut has been considered by authorit as an annual, its reappearance in spite of control measures led to thorough search in 1950 to determine the source or sources of annu growth. As soon as vegetative parts appeared in the spring, lar numbers of individual plants were removed carefully to determi from what they were growing. The bottoms of these water areas we raked carefully for any traces of vegetative parts that might have su vived overwinter. In the late summer and autumn, as temperatu gradually declined, observations were made to determine the fate the current season's growth of water chestnut.

In order to learn whether the annual growth in ponds cleared that no seeds were formed was coming from seeds lying dormant fro previous years, or from seeds being washed in from untreated are hardware cloth cages 10 feet square and 3 feet deep were anchored means of cedar posts upside down in ponds at Rexford and Crescen The pond at Rexford was connected to the Mohawk River duri high water while portions of the pond at Crescent were not treat in 1950. These cages were inspected through the winter and the fo lowing growing season.

Germination, Emergence, Flowering, and Seed Maturation

In 1950, 1951, and 1952 observations were made in the vicini of the Mohawk River to determine the approximate date when wat chestnut seeds germinated. Records were kept on when the wat chestnut foliage became crowded enough to be forced out of t water, so that spraying operations might be started. Records were al kept on the first appearance of the flowers, as an indication of wh control operations had to be started to prevent seed formation. O servations also were made on the maturation of seeds as an indicati of when control operations would no longer be effective.

Viability and Germination of Seeds

In September, 1949, 50 seeds of normal size were collected fro the Mohawk River and placed in a half-inch mesh, hardware clo cage, 3 feet in all dimensions. This cage was placed in about 18 inch of water in a backwater of the Lisha Kill, a tributary of the Mohaw River. It was removed from the water so that the seeds could examined for germination on June 2, 1950.

Observations in May, 1950, on the small size of some of the erminating seeds, led, in October of that year, to the testing of the arious sizes of seeds obtainable at that late season. Two cages made f hardware cloth, each 3 feet in all dimensions, were placed in about 8 inches of water in Allan's Pond at Crescent. The first cage was used o hold 100 medium-sized seeds, three-fourths to an inch in diameter, ıken from untreated plants in the nearby Mohawk River. In the econd cage were placed 50 seeds of the smallest size in which a firm ed coat could be found, plus 50 more seeds of slightly larger size five-eighths to three-fourths inch in diameter). These seeds were all xamined on May 31, 1951, to determine percentages of germinated, ormant, and decayed seeds.

NSECT PESTS

In the summer of 1950, collections were made of the one species f insect which could be found causing any injury to the water chest- ut foliage. These were submitted to the State Entomologist's office r identification.

CONTROL OPERATIONS

Control operations involved observations on the methods in use o to that time to learn why they were not effective, and the testing other methods and materials that might yield more satisfactory sults.

NDERWATER MOWING

In the summer and fall of 1949 and 1950, observations were made n the procedures and results obtained from the underwater cutter oats operated by the U. S. Army Engineers. Observations were made garding the water areas that could be mowed, methods of disposal the rosettes and stems cut loose, the effect of cutting upon seed oduction both from the first rosettes cut loose and from the growth t away by removing the same areas.

In early September, 1949, personnel of the water chestnut control oject (P-R Project 31-D) placed two cages of half-inch mesh hard- are cloth, 10 x 10 x 3 feet in dimension, in a backwater of the Lisha ill near Niskayuna on the Mohawk River. In the first cage were aced 50 first-growth rosettes of water chestnut, each bearing several eds, cut adrift by the mowing operations of early July. The second ge was used to contain 50 second-growth rosettes, representing re-

growth from underwater stems after the first cutting, and which ha been cut adrift by the mowers in early August. On October 6 eac rosette in the second cage was reported to bear "several small fruits"

Between June 2 and 12, 1950, these cages were removed from th water so that seeds present and numbers germinated could be counte

Seed Suppression in Isolated Ponds

In order to determine in a practical way the number of yea dormant seeds would continue to produce new plants, after annu seed production had been suppressed, isolated ponds were selected an then kept free of water chestnut growth by hand pulling all plan from 1950 through 1952. Each area was visited at least once, som times two or three times, for this purpose. Several of these areas ha been treated by one means or another in previous years.

1. A 1-acre pond along New Scotland Road, near Albany, whic had been cleared by hand in 1949 was kept clear by han pulling in subsequent years.
2. A small, isolated infestation in Dunham's Creek, tributary Lake George, which had been cleared in 1948 and 1949, w similarly cleared by hand pulling each year.
3. Tomhannock Reservoir, near Troy, from which three sma infestations had been removed by hand pulling in 1947, 194 and 1949, was treated the same way each year.
4. Carswell Pond, a former backwater of the Champlain Can at Fort Miller which had been cleared by hand pulling i 1949, was similarly cleared in subsequent years.
5. A 3-acre pond at Rexford, a backwater of the Mohawk Riv which had been infested at least since 1930 and partiall cleared by spraying with 2,4-D in 1948 and 1949, was clear in 1950 with a small Hockney weed cutter boat, and in 195 and 1952 by hand pulling. In October, 1950, two hardwa cloth cages, each 8 x 8 x 3 feet in size, were anchored upsi down in this pond by posts to determine whether new growt each year was coming from nuts being washed in from th river, or from dormant nuts in the mud on the bottom.
6. Aqueduct Pond, a backwater of the Mohawk River at Aqu duct about 9 acres in size which had been partially cleared i 1948 and 1949 by treatment with 2,4-D, was cleared by han in subsequent seasons.

TESTS OF VARIOUS HERBICIDES

As previously stated, the damage claims following the herbicide spraying operations in 1948 led to a decision to halt this type of control measure, except for isolated situations, until safer methods could be found. The testing of various herbicidal materials began on an advisory basis in the summer of 1949, and was continued as a regular part of the project until the fall of 1952.

1949 TESTS In 1949 the area known as Rexford Pond, an abandoned backwater of the old Erie Canal, was sprayed in early July by the control crew with an unmeasured but "heavy" concentration of the isopropyl ester of 2,4-D in fuel oil. Because some water chestnut plants were found still growing, though contorted, 50 of the rosettes were gathered and placed in a hardware cloth cage, 10 x 10 x 3 feet in size, in a backwater of the Lisha Kill near Niskayuna. On October 1 only two small fruits were found attached to one of these rosettes. On June 12, 1950, the cage was removed so that seeds and plants, if any, could be counted.

1950 TESTS Marth and Mitchell (1949) showed that the acid, sodium salt and certain amine salt formulations of 2,4-D were nonvolatile under laboratory conditions. In view of this it was decided to test under field conditions the nonvolatile formulations of 2,4-D and 2,4,5-T as well as the volatile formulation previously used.

In 1950, three ponds adjacent to the Mohawk River near Crescent and bearing dense growths of water chestnut annually, were chosen for the tests. For lack of official names, these will be referred to as Crescent Pond (along the Cohoes Road), Allan's Pond (south of Crescent Pond), and Power House Pond (near the power station at Crescent Dam).

A series of quarter-acre plots was laid out in each pond, separated from each other by strips at least 50 feet wide which were cleared with a small Hockney weed cutter. For comparing various concentrations of the same herbicide, some plots were divided in half. Solutions were applied by means of high pressure knapsack sprayers, except for the 4-pound-per-acre rates which were applied by means of a power sprayer. Spraying was done from the stern of a rowboat, pulled across each plot by a rope at a predetermined rate to get proper coverage. All solutions were applied at the rate of 50 gallons per acre. Spraying was done when the air was calm and when rain was not imminent.

Application of herbicides was started on July 12 and complete on July 24, except for the 16-pound-per-acre rates which were applie on August 23 and 24 to determine whether viability of seeds could b affected by late treatment. Table 1 shows the herbicides tested, th diluents used, and the concentrations of herbicides employed. Th number of pounds per acre indicates the strength of the herbicid expressed as pounds of acid equivalent applied per acre.

Table 1. Herbicides Tested for Water Chestnut Control in 1950

Herbicide	Concentration in pounds per acre	Diluent
2, 4-D isopropyl ester	8, 16	#2 fuel oil
2, 4-D, alkanolamine salts	2, 4, 6, 8, 16	pond water
2, 4-D, alkanolamine salts	4, 8, 16	#2 fuel oil
2, 4, 5-T low volatility esters ("Esteron 245")	2, 4, 6, 8, 16	pond water
2, 4, 5-T, low volatility esters ("Esteron 245")	8, 16	#2 fuel oil
2, 4-D and 2, 4, 5-T mixture ("Esteron Brush Killer")	8 and 8	pond water
#2 fuel oil only	....	....

Observations were made at frequent intervals to determine th effect of the treatments until all plants began to disintegrate in th fall. Treatments were not considered effective unless all plants wer killed or seed formation was completely inhibited.

From the plot which had been sprayed with the amine salt o 2,4-D in water at a 16-pound-per-acre rate, 55 seeds were collected i October and placed in a hardware cloth cage to determine whethe the late spraying with herbicide had in any way affected the viabilit of seeds already formed. Germination counts were made on May 3 1951.

1951 Tests Preliminary tests of herbicides were started o June 15, 1951, when water chestnut foliage began to be forced ou of the water by the density of its growth, to determine how early effec tive spraying could be done. Beginning on June 27 and ending July 1 a series of tenth-acre plots was laid out in Crescent Pond. These wer contiguous, separated by guide lines of grocer's string. Spraying agai was done by means of high-pressure knapsack sprayers from a row boat. Operations were started at dawn when air movements wer negligible, and halted as soon as sprays were observed to drift, or rai

ABLE 2. HERBICIDES TESTED FOR WATER CHESTNUT CONTROL IN 1951

Herbicide	Concentration in pounds per acre	Diluent
4-D, alkanolamine salts	8	pond water
4-D, alkanolamine salts	2, 4, 6, 8, 16	#2 fuel oil
4-D, butoxy ethanol ester	8	pond water
4-D, butoxy ethanol ester	8, 16	#2 fuel oil
4-D sodium salt	8	pond water
4-D octodecyl ester	4, 8	#2 fuel oil
4-D, low volatility ester (Dow H-1095)	8	#2 fuel oil
4, 5-T, propylene glycol butyl ether esters	8	pond water
4, 5-T, propylene glycol butyl ether esters	8	#2 fuel oil
4-D and 2, 4, 5-T mixture	4 and 4	pond water
4-D and 2, 4, 5-T mixture	4 and 4	#2 fuel oil
nmonium sulfamate	8	pond water
ntachlorophenol	8	#2 fuel oil
aleic hydrazide	8	pond water

reatened. Table 2 shows the herbicides, diluents, and concentrations ıployed.

Between July 18 and August 16 large areas of water chestnut were rayed with herbicides by means of a 25-gallon power sprayer from a wboat, to determine what results might be expected. In Red Rock ıy, Lake Champlain, approximately 2 acres were treated on July 18 a rate of 8 pounds per acre with 2,4-D, alkanolamine salts in fuel . The rest of the infestation, estimated at 5 acres, was sprayed with e same concentration of 2,4-D in water.

On July 25 and 26 Allan's Pond was sprayed by means of the power rayer, one half with 2,4-D, alkanolamine salts in pond water, the her half with 2,4-D, butoxy ethanol ester in fuel oil, each at the ound rate.

On August 16 and 17 Power House Pond was treated by means the power sprayer, using 8 pounds per acre of the butoxy ethanol .er of 2,4-D in fuel oil. This operation was interrupted on the 16th a severe thunderstorm that raised the pond level 5 feet.

On August 15 a series of test strips was sprayed in the Mohawk ver using the power sprayer mounted on the Hockney weed cutter. ıe gun-type spray nozzle was held flat on the barge deck, while the ed of the barge was regulated to get approximately an 8-pound-r-acre coverage of the alkanolamine salts of 2,4-D in water. Cover-e varied between 12 and 15 feet so that it required approximately hour to cover an acre by this method.

1952 Tests In 1952 the water chestnut foliage was consid ered sufficiently emerged near Halfmoon Beach on the Mohawk Riv by June 18 so that test strips were sprayed, using fuel oil solutions the 8-pound rate of 2,4-D alkanolamine salts, and 2,4-D, triethano amine salt.

Beginning June 26 and ending July 23, herbicides were tested o water chestnut in the Mohawk River at Crescent as shown in Table Each plot was approximately 20 x 175 feet, or 0.08 acre, the are normally covered by one application from a 4-gallon knapsack spray operated from the stern of a rowboat. Plots were contiguous, beir delineated by string lines. Spraying was started at dawn and halte whenever air movements exceeded 3 miles per hour, or when rai threatened.

Table 3. Herbicides Tested for Water Chestnut Control in 1952

Herbicide	Concentration in pounds per acre	Diluent
2, 4-D, alkanolamine salts	8	#2 fuel oil
2, 4-D, alkanolamine salts	2, 8	pond water
2, 4-D, alkanolamine salts	2, 4, 8	pond water, plus ½ ounc DuPont Spreader-Sticke
2, 4-D, dimethylamine salt	8	#2 fuel oil
2, 4-D, dimethylamine salt	2, 8	pond water
2, 4-D, dimethylamine salt	2, 4, 8	pond water, plus ½ ounc DuPont Spreader-Sticke
2, 4-D, dimethylamine salt	8	pond water, plus ½ ounc Triton B-1956 spreade sticker
2, 4-D, triethanolamine salt	8	#2 fuel oil
2, 4-D, triethanolamine salt	2, 8	pond water
2, 4-D, triethanolamine salt	2, 4, 8	pond water, plus 1 ounc DuPont Spreader-Sticke
2, 4-D, propylene glycol butyl ether ester	8	#2 fuel oil
2, 4-D, propylene glycol butyl ether ester	2, 8	pond water
2, 4-D, propylene glycol butyl ether ester	2, 4, 8	pond water, plus ½ ounc DuPont Spreader-Sticke
2, 4-D, butoxy ethanol ester	2, 8	pond water
2, 4-D, butoxy ethanol ester	2, 4, 8	pond water, plus ½ ounc DuPont Spreader-Sticke
dinitro-o-sec butyl phenol ("Premerge")	1	pond water

Various formulations of 2,4-D were tested, in various concen trations, using fuel oil or water as the diluent and testing the effec of a commercial spreader-sticker. The various amine salt formulatio

ere compared because of the report by Cross (1952) that the tri-hanolamine salt of 2,4-D caused less injury to cranberries than the opropanolamine or the alkanolamine salts.

FINDINGS

The results of these observations and experiments showed some romise of successful water chestnut control, pointed out several azards, and indicated the need for testing large-scale control methods.

LIFE HISTORY OBSERVATIONS

Observations on certain of the life history processes cleared up me misconceptions, delimited the period within which control opera-ons must be conducted, and indicated that little help could be ex-ected from the known insect pests.

OURCE OF ANNUAL GROWTH

In 1950, germinated seeds and small plants were first observed May 17, in Burden Pond near Troy, in water from 3 inches to foot deep. Raking the bottom to determine the source of growth in ery instance yielded plants growing from seeds of varying sizes, some ss than one-half inch in diameter. No evidence was found of over-nter survival of leaves, stems, or roots. Observations later in the ason showed the progressive and ultimately complete disintegration all parts except the seeds, as water cooled to the freezing point.

It proved difficult to keep the various cages anchored on the ttom of various ponds overwinter because of ice action, but enough ayed in place so that it was obvious that new growth came from eds lying on or in the mud, rather than from seeds being washed from the adjacent Mohawk River. Large numbers of carp kept the ud constantly churned up so that seeds were being buried as well uncovered at all times.

ERMINATION, EMERGENCE, FLOWERING AND SEED MATURATION

In 1950, germinated seeds and small plants were first observed Burden Pond on May 17. In 1951, small plants were first observed May 16 at the same locality. In 1952 a single germinated seed was served in Power House Pond on April 30, but germinated plants re not found in Burden Pond until May 14.

By May 25, 1950, young plants could be found in water as much 2 feet in depth in all the ponds around the Mohawk River. In

Burden Pond, rosettes were beginning to reach the surface in these shallow waters, but in the Mohawk River proper, where the water was cooler, no plants could be found. By June 25 foliage was being forced out of the water by crowding of the water chestnut plants.

Characteristics of water chestnut: (left) rosettes and submerged stems; (right) germinated seeds of various sizes (papers 8½ x 14 inches).

In 1951, plants were emergent along the Mohawk at Crescent Pond on June 15, while in the same location crowding became apparent about June 20. In 1952, the date of emergence was June 11, while foliage was crowded out of the water by June 18.

In 1950, flowers were first observed on June 28 at Crescent. In 1951 the date was June 27, while in 1952 the first flowers were seen on June 25.

Water chestnut fruits were considered to be mature when they broke away from the parent plant and sank to the bottom. In 1950, this was first observed about August 15, although full-sized fruits were found as early as July 22 in Carswell Pond, where the water depth in which the plants grew was less than 2 feet and where the water was correspondingly warmer. August 15 was used as the date beyond which hand pulling or underwater cutting of plants for the first time in a particular season would be useless because of the dehiscence of fruits.

Viability and Germination of Seeds

The 50 normal-sized seeds of the 1949 crop, caged over winter, were examined on June 2, 1950. All were found germinated and

growing, indicating 100 per cent germination for this size of nut held under these conditions.

Seeds collected for germination tests in October, 1950, were examined on May 31, 1951. Of the smallest seeds obtainable, 11 per cent had germinated. The slightly larger seeds had a germination rate of 26 per cent, while the medium-sized seeds showed a 70 per cent germination. This indicated that no seed formation at any part of the season could be permitted if eradication was to be complete. Examination of the ungerminated seeds later in the summer revealed that they were all decayed and that under the conditions provided no seeds had remained dormant.

Insect Pests

Both larvae and adults of a small native beetle, identified as *Galerucella nymphaeae*, were exceedingly abundant on the emergent foliage of the water chestnut in 1950, less so in 1951 and 1952. Considerable feeding on the foliage was apparent, but no serious injury to water chestnut resulted. It is interesting that a related species, *Trapa bispinosa*, cultivated for the seeds in northwestern India, is parasitized heavily by a related beetle, *Galerucella birmanica* (Khatib, 1934).

Effects of Control Operations

Observations on and tests of various control operations showed the importance of the timely destruction of all the water chestnut plants each year, if control was to be achieved, and that the application of a suitable herbicide offered a more simple, rapid means of achieving control in a shorter span of years than did mechanical methods.

Underwater Mowing

The underwater weed cutters used until 1952 operated by cutting off the stems of water chestnut below the rosettes. Cut portions were then pushed out of the way into the main channel of the Mohawk River where they drifted about or floated slowly downstream. Cutting operations started about July 1 and ended about August 20. An attempt was made each year to cut over the area covered a second time to eliminate the regrowth from the underwater stems remaining.

It was apparent that the cut rosettes continued to mature seeds as long as they remained in the water, so that the seeds merely were deposited somewhat downstream.

When the cages into which the cut rosettes had been placed i 1949 were examined on June 5, 1950, it was found that the cag receiving the 50 first-cut rosettes contained 87 plants still attached t the seeds, indicating that, although the leaf rosettes had been separate from most of the absorptive tissue growing from the stems, enough ha remained to permit the rosettes to mature seeds.

The second cage into which the 50 second-growth rosettes ha been placed, also was examined on June 5, 1950. This cage had bee submerged by high water during the previous week, so the two sma floating plants found, still attached to small seeds, may have bee washed into the cage. No other viable seeds could be found within th cage. In view of the fact that seeds were observed on the plants in th previous fall, however, it would have been possible for these to matur indicating that even regrowth must be removed if seed formation to be suppressed completely.

It was observed that mowing operations in the channel near th old Niskayuna railroad station had resulted in eliminating the wate chestnut reproduction in the areas where the water depth was greate than 4 feet. There was an abundance of plants, however, each year i the shallow water that the cutter barges could not reach, so tha cessation of mowing would result eventually in the channel bein reinfested and closed over each summer by water chestnut plants.

Seed Suppression in Isolated Ponds

The effect of halting seed formation each year by removing a water chestnut plants from certain ponds is shown in Table 4. Th New Scotland Road Pond apparently had been infested only a sho time when it was first cleared in 1949. Since then a single plant ha been found nearly every year. It is suspected that seeds first reache this pond via bait dealer's nets, and that this method of infestatio continued to create a problem.

The Dunham's Creek infestation was reduced by 1952 to a sing plant, but since that time a few plants have been located each yea This stream is in the midst of a large marsh, with few permanen landmarks, so plants may have been missed in some manner, in som seasons.

Tomhannock Reservoir yielded the greatest amount of evidenc of reinfestation. Being a public water supply, it has few suitable site for water chestnut to grow. No plants could be found in 1952, but i 1953 plants were found in a cove where none had been seen sinc

TABLE 4. EFFECT OF HALTING SEED FORMATION BY REMOVING WATER CHESTNUT PLANTS

Pond	Degree of infestation in 1950	Number of plants removed*					
		1947	1948	1949	1950	1951	1952
New Scotland Road Pond	scattered plants	..	..	§	25	1	1
Dunhams Creek	scattered patches	..	§	§	28	11	1
Tomhannock Reservoir	three small patches	eight	§	§	23	10	‡
Carswell Pond	scattered patches	..	..	§	one	25	17
Rexford Pond	completely covered	..	†	†	many	several	210
Aqueduct Pond	completely covered	..	†	†	many	several	one

* Numerals represent number of individual plants; words represent number of boatloads.

§ Cleared, no record of amount removed.

† Partially cleared by spraying with 2,4-D, isopropyl ester.

‡ Water chestnut plants appeared in 1953 in one area where they had not been found since 1949, indicating reinfestation.

1949. There is a small but steady amount of illegal fishing as well as netting for bait each year, and the Conservation Department's salvage crew operates nets legally in this reservoir, so that reinfestation is an annual threat.

In Carswell Pond a substantial reduction was effected by 1952, with an assist by muskrats in the latter year. The water over much of the pond is less than 2 feet deep, with a dense growth of *Anacharis canadensis*, so that the water warms rapidly in June. Water chestnut appeared late (May 31, 1951) but by July 21 seeds were as large as have ever been seen. Bait dealers were encountered using their nets here at almost every visit. Several of these acknowledged that they had just been netting in the Mohawk River or the Hudson River at points where water chestnut was abundant.

Rexford Pond, when first seen in 1950, was completely covered with a dense mat of water chestnut, which had been observed there for at least 15 years previously. At high water this was connected to the Mohawk River a few yards away. Partial control was obtained with 2,4-D in 1948 and 1949. An attempt to learn whether the sprayed rosettes in 1949 had matured seeds failed when the cage in which the rosettes had been placed was inundated. Only two small seeds had been seen attached to the plants in the fall of 1949, but the cage contained 24 plants when examined on June 12, 1950.

In 1950 this pond was cleared by means of a small Hockney weed cutter and hand removal of all water chestnut plants. In subse-

quent years plants were removed by hand, so that by 1952 the numbe removed was 210. This was encouraging, in view of the high organi content of the mud and the water, and the intermittent connectio with the Mohawk River which was a potential source of reinfestatio

Aqueduct Pond, in reality a backwater of the Mohawk River an infested prior to 1935, could not be cleared satisfactorily by 1952 although there was a distinct reduction in the numbers of plants foun each year. The bottom was a deep, rich mud with an abundant suppl of water chestnut seeds, so that regrowth from dormant seeds ma prevail for a number of years.

Tests of Various Herbicides

The experiments carried on with the various herbicides teste have been described. The results are presented correspondingly for th work done each year.

1950 Tests Results from the 1950 tests of herbicides showe that the various formulations of 2,4-D and 2,4,5-T used were capabl of killing water chestnut plants. Fuel oil alone caused injury to th foliage that was apparent within 15 minutes and that resulted in th destruction of the affected leaves. Submerged leaves and the protecte growing parts of stems were uninjured, so that within a week ne foliage was at the surface. Oil solutions offered the advantage o being visible immediately after application, so that the area spraye was well delineated.

Oil solutions took effect more rapidly than water solutions, an gave somewhat more complete coverage, possibly because the herbicid was not diluted so rapidly as when in water solution. An effectiv application cleared the water of all water chestnut growth in abou 60 days. The 8-pound acid equivalent rate per acre gave the mos uniform results. As the concentration was reduced, the number o water chestnut plants surviving was increased, particularly whe foliage was not crowded out of the water. The 2-pound rate wa considered ineffective under all conditions. The isopropyl ester o 2,4-D gave the most rapid kill, but because of its dangerous volatility was used only for comparative purposes. Solutions of 2,4-D an 2,4,5-T were equally effective, but the cost per gallon of the latter wa nearly three times greater. The application of 16 pounds per acre gav the most rapid kill of all the various concentrations, but such a con centration was found unnecessary. Of the 55 seeds collected fro one 16-pound-per-acre plot, 26 (or 47 per cent) germinated, indicat

ing that late spraying did not inhibit the maturation of seeds already formed at the time of treatment.

1951 TESTS All the formulations of 2,4-D and 2,4,5-T tested destroyed water chestnut plants at the 8-pound-per-acre rate, with a more rapid kill from the various ester formulations. The octodecyl ester is considered significantly volatile, while the danger from the volatility of the butoxy ethanol ester and the propylene glycol butyl ether esters is not known. Ammonium sulfamate and pentochlorophenol caused only the contact type of injury and did not kill the water chestnut plants. Maleic hydrazide was completely ineffective.

Observations on the sprayed area in Red Rock Bay, Lake Champlain, showed that in a very dense growth of water chestnut, water solutions were less effective than oil solutions, and that the herbicide removed only the top layer of plants, so that submerged plants were released and enabled to grow. Under such conditions a respraying of the infested area would be necessary to be sure of destroying all the current season's growth.

Observations on the test strips sprayed on the Mohawk River in mid-August, using a gun-type nozzle on a power sprayer, showed that the gun-type nozzle could not be operated efficiently from the weed cutter barge which could not be run slowly enough. Because of the rate of travel and the disturbance in the wake of the barge, spraying could be done only on one side, in a strip averaging about 15 feet in width. It was interesting to note that, although this spraying was done after many seeds had matured, a significant effect was obtained, so that in the spring of 1952 the sprayed strips showed up as areas clear of water chestnut plants. These areas eventually were filled by the crowding in of water chestnut plants from unsprayed areas.

1952 TESTS The test sprayings of June 18 did not yield a satisfactory kill of water chestnut. Many of the rosettes when sprayed lay at the surface of the water rather than crowded out of it, so that apparently the quantity of herbicide which hit the foliage was insufficient to cause death of the plants.

The heavy molecule, low volatility ester formulations again caused a more rapid kill than the various amine salt formulations. There was no observable difference in the results obtained from the various amine salt formulations. The addition of a spreader-sticker produced a more uniform injury to water chestnut at the 2- and 4-pound concentrations in water solutions, but these applications were not equal in effectiveness to those at the 8-pound rate. The use of "Premerge" (dinitro-o-sec

Effect of spraying water chestnut with 2,4-D at rate of 8 pounds per acre (above), part of Crescent Pond before treatment on July 24, 1951; (below) same area on September 10, 1951.

utyl phenol) caused only contact type injury to the water chestnut oliage, from which the plants recovered in about 2 weeks by the roduction of new leaves. This was the only herbicide tested in 1952 hich caused observable injury to fish (fry of sunfish, bullheads, and arious minnows). Oil solutions again gave more uniform and rapid ill than did water solutions.

DISCUSSION

If water chestnut is to be controlled, the method or methods used ust be applicable to the entire area infested each year, must be 100 er cent effective each season, must be continued until the supply of ormant seeds is exhausted, must not injure desirable vegetation in- luding agricultural crops, and must be economically feasible. Hand ulling is feasible only for small, isolated infestations, and perhaps fter large-scale methods have reduced infestations to widely scattered lants. Use of underwater cutters was abandoned because they could ot reach large areas of water chestnut in shallow water or behind nd barriers, and because they did not remove the cut vegetation from e water, but left it to mature seeds.

Herbicides offer the greatest promise of controlling water chestnut ecause they can kill the plants in place and because by means of erial application they can be applied to the entire infested area in a latively short time. Until the nonvolatile formulations of 2,4-D were veloped, the use of 2,4-D was extremely hazardous, because a very ght amount of vapor drifting from sprayed areas could damage such nsitive crops as beans and tomatoes. With the nonvolatile forms there still hazard from accidental direct spraying of crops, or from drift the spray while it is being applied if wind movement is in the wrong rection or excessive. Experimental spraying from power and knap- ck equipment was halted when there was any noticeable drift of the ray, which occurred when the breeze exceeded 3 miles an hour. 1952 Allan's Pond was sprayed completely and successfully, without jury to Mr. Allan's garden of tomatoes and beans which was 30 feet m the edge of the pond, by choosing a day when air movements, any, were away from the garden area.

The most promising method for treatment of the entire area of ter chestnut infestation would seem to be by applying a non- latile formulation of 2,4-D by means of helicopters. Zimmerman *al.* (1950) demonstrated that water hyacinth could be controlled Louisiana by helicopter applications of the amine salts of 2,4-D.

It was found possible to cover 600 acres a day by helicopter, as con trasted to 15 acres daily by power equipment mounted on a boat.

Since there are crop fields adjacent to the water chestnut area in the Mohawk and Hudson Rivers, it would be necessary to determin by experimentation elsewhere the safety margins necessary to preven injury by drift of sprays, and to zone the infestations carefully i relation to crops. Because of load limitations of helicopters it woul be necessary to apply the spray in the form of the 40 per cent solutio as it comes in the containers, rather than as the medium gallonag dilutions tested so far in the power sprayers.

Another potential hazard would be the unwitting use of wate from the sprayed areas or immediately downstream from them fo irrigation puposes, or for applying fungicides to orchards and crop While the main water areas infested are normally too heavily pollute for such uses, precautionary measures would be required.

CONCLUSIONS

No evidence was found that water chestnut is other than a annual plant, reproducing solely by seeds, which may all germina the next season, but which are able to remain dormant for at lea several years before germinating. By annual removal of all wate chestnut growth to suppress seed formation, isolated infestations wer reduced from dense mats of foliage to as few as one plant per yea in a period of 3 to 4 years. The smallest seeds obtainable with a firm seed coat, collected in the middle of October, had a germination rat of 11 per cent the following spring, indicating that no seed formatio whatever can be permitted, if control is to be effective.

In the vicinity of Albany water chestnut growth begins to appea about May 15, and the first flowers are usually observed about Jun 27, so that control measures would have to be started about the latte date to prevent seed formation. Seeds are sufficiently well developed b July 15 so that use of herbicides would be relatively ineffective aft that date in halting seed production, while hand pulling of plants fo the first time in a season would be futile after mid-August when th seeds start to drop off the plants and sink to the bottom.

Only one insect, a leaf beetle, was found to feed on water chestnu foliage, without serious damage to the plants. No fungus diseases wer observed. The possibility of locating insect or fungus controls seem remote.

Rosettes cut loose from the stems but left in the water continu to mature seeds, so that underwater mowing that does not involv

removal of cut portions from the water is ineffective. Underwater cutter boats are likewise ineffective because vast areas of infestation occupy water too shallow to be traversed.

The most promising method of control tested involved the application of medium-gallonage sprays of nonvolatile formulations of 2,4-D by means of pack sprayers and boat-mounted power sprayers. Fuel oil solutions showed up more rapidly and gave somewhat better coverage and a faster kill than did water solutions. The recommended rate is 50 gallons of solution per acre, containing 8 pounds acid equivalent of the amine salts of 2,4-D.

Tests elsewhere have shown that boat-mounted equipment can spray about 15 acres a day, whereas applications by helicopter could cover 600 acres a day. In view of the relatively short period for treatment—the last week in June until July 15, approximately—application by helicopter is considered a promising approach to the problem, although it would need to be thoroughly tested to ascertain the safety factors required and the procedure to be followed.

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COMPARATIVE TOXICITIES OF POTASSIUM CYANIDE AND POTASSIUM CUPROCYANIDE TO THE WESTERN BLACK-NOSED DACE *(RHINICHTHYS ATRATULUS MELEAGRIS)*

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ABSTRACT

The toxicities of potassium cyanide, and of potassium cuprocyanide havi cyanide-to-copper mol-ratios of 4.0, 3.75, and 3.0, were measured by a flo through procedure. The toxicity decreased as the ratio of copper to cyani increased. The 24-hour median tolerance limits for KCN and for the 4 3.75, and 3.0 mol-ratios were 0.22, 0.38, 0.47, and 0.71 p.p.m. CN, respe tively; the 4-hour median tolerance limits were 0.26, 0.53, 0.69, and 1. p.p.m., respectively. These values were for one species of minnow, the weste black-nosed dace, and for the given conditions of temperature, pH, and d solved oxygen. In spite of the decrease in toxicity due to the presence copper, cuprocyanide solutions are sufficiently potent to constitute a pollutio hazard when present in industrial wastes.

It has long been known that the chemical and physico-chemic properties of solutions of such simple cyanides as potassium cyanid become markedly modified upon the addition of certain heavy-met salts. The changes are such that most of the cyanide group in the metal-cyanide solutions are believed to be in the form of compl metallo-cyanide anions. Solutions of the complex cyanides have im portant industrial uses, notably in the electroplating of copper, zin cadmium, gold, and silver. Therefore, knowledge of their toxicities of practical interest in connection with pollution abatement.

Very little of the published work on the toxic effects of cyanid on fish life has dealt with the metallo-cyanides. Burdick and Li schuetz (1948) reported the increased toxicities of ferro- and fer cyanides when exposed to light. The work of Milne (1950) indicat that nickel-cyanide corresponding to a mol-ratio of 1:3.05 was n lethal to common goldfish during a 24-hour exposure period wh the total cyanide concentration was equivalent to 104 p.p.m. CN. O the other hand, Turnbull, DeMann and Weston (1954) found that cadmium-plating solution (composition not given) was more toxic bluegill sunfish than was indicated by its cyanide content; the 24-ho median tolerance limit was equivalent to 0.18 p.p.m. CN, where the 24-hour median tolerance limit of potassium cyanide was 0.2 p.p.m. CN. No other references are known to the authors. Southga

1948) did not give any, nor could any be found in Biological Abracts for the years from 1947 through 1954.

The paucity of information on the toxic effects of the metallocyanides prompted the authors to undertake a series of experiments ith cuprocyanide. The work was done with cyanide-to-copper molatios[1] which corresponded to what might be expected in the electroplating industry. Blum and Hogaboom (1945, p. 295-297) gave some epresentative copper-plating formulas with cyanide-to-copper molatios of 3.5 and 3.8.

PROCEDURE

Western black-nosed dace *(Rhinichthys atratulus meleagris)* were sed for the experiment. The fish were obtained, by seining, from reen Gulf Brook, at Springwater, Livingston County, New York. hey were brought to the laboratory at Rochester and placed in quaria, where they were kept for not more than 2 weeks prior to ie first test. Three separate lots were used, collected in November or ecember of 1952, 1953, and 1954. Very little to no mortality took lace during the acclimatization periods and no mortality occurred the fish stock during the test periods. Fish which survived exposure test solutions were not used for subsequent experiments.

The test vessels were jars of about 400 milliliters capacity. Each ar was made by cutting off the upper part of a 500-milliliter Pyrex spirator bottle with outlet for tubing (Corning #1220). One fish at time was used in a jar. A continuous-flow technique was used, the st solution entering the jar at the liquid level and discharging to aste via the outlet. A piece of bent glass tubing of appropriate size onnected to the outlet by a short length of rubber tubing served to ontrol the solution in the test jar at a level corresponding to a volume about 275 milliliters.

Five test jars were used together, being connected in parallel to reservoir (a 4½-gallon Pyrex jar with open top and a bottom tubuture for rubber stopper, Scientific Glass Apparatus Co. #J4150) ept on a shelf about 5 feet above them. The rate of flow through ie test jars was controlled by manual operation of Hoffman screw amps on the branches of the delivery tube from the reservoir, and

[1] The cyanide-to-copper mol-ratio is the ratio of gram-moles of total cyanide to gram-atoms of total copper. The mol-ratios were calculated from the equivalent expression $\frac{\text{p.p.m. CN}/26}{\text{p.p.m. Cu}/63.54}$, where the total cyanide concentration is expressed as p.p.m. CN and the total copper concentration as p.p.m. Cu.

was maintained at about 500 to 600 milliliters per hour. The solutio in the reservoir was drained off every 3 or 4 hours (without drainin the test jars) and replaced with freshly prepared solution of the sam composition.

All stock solutions used for preparing the test solutions were mad up in distilled water. Stock solutions of potassium cyanide (made fro the reagent grade dry compound) contained in addition about 0. gram sodium carbonate per 100 milliliters, and were standardized b titrating with standard silver nitrate using a 0.02 per cent solution p-dimethylaminobenzylidene rhodanine in acetone as indicator (Rya and Culshaw, 1944). Cuprocyanide stock solutions were prepared b dissolving weighed amounts of J. T. Baker's Reagent Grade Cupro Cyanide (calculated total CN = 29.05 per cent; total CN found 29.12 and 29.05 per cent in duplicate determinations) in the appro priate volumes of stock potassium cyanide solutions. All stock solutio were stored in a refrigerator when not in use. Cuprocyanide sto solutions were discarded after 48 hours, being replaced by newl prepared batches.

Each batch of test solution was made by adding a calculate volume of stock solution to 16 liters of Rochester tap water. Th largest volume of stock solution ever used was 10 milliliters. The wate after being drawn from the tap, was first warmed to room temperatu by means of an immersed incandescent lamp. The Rochester wat supply fluctuates between 7.7 and 8.0 in pH, between 52 and 61 p.p.m in total alkalinity (as $CaCO_3$), and between 96 and 111 p.p.m. in tot solids, according to figures furnished by Mr. William A. Ryan, chemi at the Rochester sewage treatment plant. Frequent determinations pH and total alkalinity in samples drawn from the tap in the labor tory have given results agreeing with these values. The dissolve oxygen of the water was about 10 p.p.m. determined by the sulfam acid modification of the Winkler method.

Test solutions and stock cuprocyanide solutions were analyzed f total cyanide by subjecting an aliquot, treated with 4 to 5 milliliters concentrated hydrochloric acid, to distillation into a few milliliters 10 per cent sodium hydroxide solution. The cyanide in the distillat was titrated with standard silver nitrate solution, using the rhodani end-point procedure of Ryan and Culshaw (1944).[2]

All the tests were made at room temperatures, which were co trolled only roughly. The temperature of the test solutions vari within a narrow range. Neither pH nor dissolved oxygen was controlle but their fluctuations were small. Most of the pH measurements we

ade electrometrically with a glass electrode and a Leeds and North-p #7663-A1 Universal pH Indicator. Between December 23, 1953 id January 13, 1954, however, colorimetric determinations were made ing Hellige indicators and glass disk standards.

A number of determinations of total cyanide and dissolved oxygen the contents of the test jars were made at the beginning of the periment. It was found that neither differed significantly from the lues found in the solution in the reservoir, and analyses of the con-nts of the test jars were therefore discontinued. It is apparent that ith the experimental set-up used there was no appreciable effect on ther cyanide concentration or dissolved oxygen concentration due to e metabolic activities of the fish.

It was found, however, that the concentration of total cyanide in e solution in the reservoir decreased, even in a 4-hour period. The crease was usually 0.03 or 0.04 p.p.m. CN, although occasionally, ith the higher concentrations, decreases up to 0.07 or 0.08 p.p.m. ere found.

Ten fish were used at each combination of total cyanide concen-ation and cyanide-to-copper ratio. No fish was exposed to a test lution for longer than 24 hours.

The end-point was the time of death of the fish. A fish was con-dered dead when no response occurred to pressure applied by a small air of tweezers to the caudal end of the vertebral column. The veezers were used after all movements of the fish had ceased and no sponse could be obtained by more gentle prodding.

DISCUSSION

The data and observations are summarized in Tables 1 through Concentrations of test solutions are given in terms of the nominal ncentration, which is the concentration, expressed as p.p.m. CN, lculated from the weight of cuprous cyanide and volume of stand-rdized potassium cyanide solution taken to prepare the stock solution.

Titrations of the distillates from the test solutions were carried out with 0.00100 molar $AgNO_3$, and it was found expedient to perform the titrations n 100-milliliter tall-form Nessler tubes. Recognition of the end-point was made easier by using two comparison tubes, each containing the same total volume, amount of NaOH solution, and amount of indicator as the sample ube, but no cyanide; one of the comparison tubes had no added $AgNO_3$, while the second had one drop of the 0.00100 molar $AgNO_3$, an amount sufficient to give a perceptible pink tint. Color changes were observed by looking down through the tubes kept in a conventional Nessler tube support. At night, and on dark days, illumination was by a fluorescent titration lamp placed in front of the support, and by an overhead incandescent lamp fixture.

Table 1. Effects on Black-nosed Dace of Cuprocyanide Solution with the Mol-ratio [CN] : [Cu] = 3.0:1

Item	Date of experiment (1953)				
	January 16	January 22	January 30	February 5–7	Februar 9–11
Cyanide concentration (as CN) in p.p.m.	3.12	2.03	1.01	0.77	0.51
pH range	7.93–8.01	7.82–7.83	7.82–7.93	7.72*	7.74*
Temperature range in degrees Fahrenheit	68½–69	68½–69	68–71	68½–71	67–70
Weight of fish in grams					
Range	0.4–2.5	0.4–1.8	0.5–2.8	0.5–2.6	0.6–2.6
Mean	1.1	1.2	1.6	1.5	1.5
Length of fish in centimeters					
Range	4.2–7.3	4.2–7.2	4.1–7.5	4.3–7.0	4.6–7.4
Mean	5.4	5.5	6.0	5.7	5.8
Time for death in minutes (figures represent individual fish)	27	36½	69	489–628	†
	28½	40	124	784–1,254	
	33	41	149	784–1,254	
	34½	42	164	681–1,267	
	35	44	243	681–1,267	
	36	44	317	832–1,418	
	37	49	381	§	
	37½	50½	403		
	39½	54½	736		
	42½	58½	792		

* Only one pH determination made during test.

§ One of the surviving fish was upright at termination of test; the remainin three were in distress, but recovered when placed in fresh water.

† No mortality in 24 hours; two of the fish lost equilibrium during the tes all the fish upright at termination.

In some instances the time of death was not accurately known becaus death occurred when no observer was present. In such cases the tim for death is given in the tables in the form of two figures, the lowe one being the latest time that it is known that the fish was alive, an the higher one being the earliest time that it is known that the fis was dead. All fish which survived that long were observed at 24 hour

Some of the observations are presented in Figure 1 as time mortality curves. Where death was not actually observed and the tim of death could be placed only within an interval, the upper and lowe limits of the interval are plotted and the line drawn arbitrarily to point midway between them. For 0.50 p.p.m. CN at a cyanide-t copper mol-ratio of 3.75:1 the observations were such that limits coul

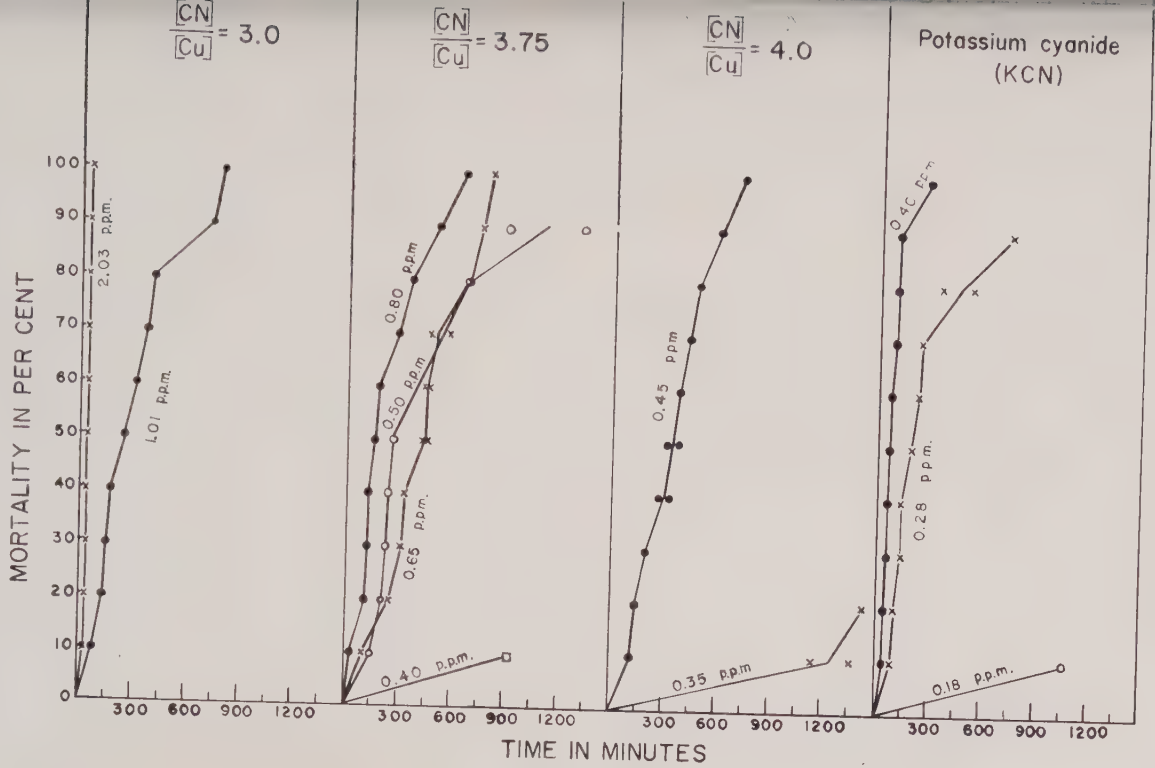

Figure 1. Time-mortality curves for black-nosed dace subjected to various concentrations of potassium cuprocyanide and potassium cyanide.

Table 2. Effects on Black-nosed Dace of Cuprocyanide Solution with the Mol-ratio [CN] : [Cu] = 3.75:1

Item	Date of experiment (1953-1954)			
	December 14–15	December 17–24	January 6–14	January 26 to February 4
Cyanide concentration (as CN) in p.p.m.	0.80	0.65	0.50	0.40
pH range	7.89–7.96	....	....	7.63–7.99
Temperature range in degrees Fahrenheit	69–71	68–72	68–72	69–72
Weight of fish in grams				
Range	1.0 2 0	0.8–3.1	0 7 2 9*	.....
Mean	1.6	1.7	1.8*	.....
Length of fish in centimeters				
Range	5 5–6 6	4 9 7 4	4 6 7 2	.. ..
Mean	6.1	6.2	6.1	.....
Time for death in minutes (figures represent individual fish)	24	101	138	915
	116	243	220	†
	119	308	222	
	120	327	232	
	159	444	262	
	176	458	360–530	
	278	433–571	424–619	
	348	677	688	
	505	748	890–1,320	
	644	801	§	

* Only nine fish weighed.

§ The lone surviving fish had lost its equilibrium during the test, and was showing signs of distress at termination.

† Five of the surviving fish lost equilibrium at one time or another during the test; the remaining four showed few or no signs of distress when under observation.

not be assigned for 60 per cent and 70 per cent mortality, and, therefore, a straight line was drawn to connect the points corresponding to 50 per cent and 80 per cent mortality. No exact times of death were observed with 0.77 p.p.m. CN at the cyanide-to-copper mol-ratio of 3.0:1, and, therefore, this curve is not given.

Inspection of Figure 1 shows that more total cyanide is required to produce a given effect when present as cuprocyanide than when present as a simple cyanide, and that more cyanide is required to produce a given effect the smaller the cyanide-to-copper mol-ratio.

The information given in Tables 1 through 4 has been used to calculate the median tolerance limits (i.e., the concentration at which

ABLE 3. EFFECTS ON BLACK-NOSED DACE OF CUPROCYANIDE SOLUTIONS WITH THE MOL-RATIO [CN] : [Cu] = 4.0:1

Item	Date of experiment (1954)		
	November 30 and December 1	December 2–11	December 13–15
vanide concentration (as CN) in p.p.m.	0.45	0.35	0.28
H range	7.68–7.80	7.70–7.89	7.71–7.86
emperature range in degrees Fahrenheit	69–70	68–69	69–69½
eight of fish in grams			
Range	0.4–3.6	0.4–2.6*	0.4–2.7
Mean	1.2	1.6*	1.4
ngth of fish in centimeters			
Range	3.8–7.6	3.8–7.1*	4.1–7.2
Mean	5.0	5.7*	5.7
me for death in minutes (figures represent individual fish)	110 132 185 315 286–368 375 437 472 590 715	1,140–1,353 1,429 §	†

Only nine fish weighed and measured.

Three of the surviving fish lost equilibrium completely at least once, and the remaining five showed other signs of distress.

No mortality in 24 hours; no loss of equilibrium was observed, but there were other signs of distress (coming to the surface, and rapid swimming).

st 50 per cent of the test specimens survived a given exposure riod) for exposure periods of 4, 8, 12, and 24 hours. The median lerance limits have been calculated by the straight line graphical terpolation method recommended by Doudoroff and fellow-members the Subcommittee on Toxicity, Section III, of the Committee on esearch, Federation of Sewage and Industrial Wastes Associations 951). The concentration was plotted on the logarithmic scale of mi-log paper against per cent survival on the arithmetic scale, using nly two points, one corresponding to a survival greater than 50 per nt and the second to one lower than 50 per cent. A straight line was awn to connect the two points, and the concentration corresponding

Table 4. Effects on Black-nosed Dace of Potassium Cyanide Solutions

Item	Date of experiment (1954)		
	February 19	December 16	December 20–22
Cyanide concentration (as CN) in p.p.m.	0.40	0.28	0.18
pH range	7.85–7.91	7.92–7.96	7.73–7.91
Temperature range in degrees Fahrenheit	71½–72	69	68
Weight of fish in grams			
Range	0.9–2.1	0.4–3.6	0.4–2.6
Mean	1.5	1.6	1.3
Length of fish in centimeters			
Range	5.7–7.3	4.1–7.7	4.1–7.1
Mean	6.4	5.7	5.5
Time for death in minutes (figures represent individual fish)	42	87	1,062
	47	93	§
	56	137	
	58	139	
	59	186	
	72	236	
	94	247	
	96	344–524	
	100	745	
	273	*	

* The one fish which survived, lost equilibrium and regained it repeatedly.
§ Four of the surviving nine fish lost equilibrium at least once.

to 50 per cent survival was read off and called the median tolerance limit. When the data did not permit the use of two partial survivals it became necessary to use a point corresponding to either 100 per cent survival or zero survival. The calculated median tolerance limits are given in Table 5.

Table 5 shows the possibility of error stemming from the fact that the time of death of some of the fish was not observed. An abnormality is found in the apparently aberrant positions of the time-mortality curves for 0.50 and 0.65 p.p.m. CN at the cyanide-to-copper mol-ratio of 3.75:1. A part of the curve for 0.50 p.p.m. CN lies to the left of the curve for 0.65 p.p.m. CN, which would be interpreted to mean that 0.50 p.p.m. CN was more toxic than 0.65 p.p.m. CN. It is probable that the reversed position of the two curves is due to random sampling fluctuations.

Table 5. Median Tolerance Limits for Black-nosed Dace of Potassium Cyanide and Cuprocyanide Solutions for Four Exposure Periods

Solution	Exposure period			
	4 hours	8 hours	12 hours	24 hours
Cuprocyanide having mol-ratio of:				
3.00:1	1.10	0.91	0.87 (a)	0.71
3.75:1	0.69 (b)	0.58 (c)	0.50 (d)	0.47 (e)
4.00:1	0.53 (f)	0.41	0.40	0.38
Potassium cyanide....	0.26	0.24 (g)	0.24	0.22

a) Survival at 0.77 p.p.m. CN could have been 70, 80, or 90 per cent; the reported median tolerance limit is midway between the values calculated for 70 and 90 per cent survival, i.e., 0.86 and 0.89 p.p.m. CN.

b) This is the mid-value between the median tolerance limits, i.e., 0.63 and 0.77 p.p.m. CN. calculated separately when one of the points corresponded to either 0.50 p.p.m. CN or 0.65 p.p.m. CN and the second point represented 0.80 p.p.m. CN. The median tolerance limit estimated from the points corresponding to 0.80 p.p.m. and 0.40 p.p.m. was 0.71 p.p.m. CN.

c) Survival at 0.65 p.p.m. CN could have been either 30 or 40 per cent, and the respective median tolerance limits would be 0.57 and 0.60 p.p.m. CN. The reported value is mid-way between the two.

d) The mid-value of the two extremes of 0.45 and 0.54 p.p.m. CN, calculated when one of the points corresponded to either 0.50 or 0.65 p.p.m. CN, respectively.

e) The mid-value of the two extremes of 0.45 and 0.50 p.p.m. CN, calculated when one of the points corresponded to either 0.50 or 0.65 p.p.m. CN, respectively.

f) By straight line graphical extrapolation; the data were not sufficient for interpolation.

g) Survival at 0.28 p.p.m. CN could have been either 20 or 30 per cent, and respective median tolerance limits would be 0.24 and 0.25 p.p.m. CN. The reported value is mid-way between the two.

In spite of these apparent deviations, a general trend is shown in Figure 1. With the exception of the 3.0:1 ratio, the range of concentration, from that at which mortality began to manifest itself to that at which mortality developed quickly, was a narrow one.

It is realized that exposure periods greater than 24 hours would be necessary if complete knowledge of the toxic properties of substances is to be obtained. For example, when some of the fish which had survived a 24-hour exposure period, but had been in distress, were placed in a 16-liter portion of the waste test solution, several died within a second 24-hour period. However, in view of limitations of personnel and facilities at the laboratory, it was not deemed absolutely necessary to continue the tests beyond 24 hours since most of the

pollution investigations made by this laboratory deal with situations i which the period of discharge of a toxic material has been limited to a period of a few hours, or even less on occasion.

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ERTAIN ASPECTS OF WATERFOWL HUNTING IN NEW YORK AS INDICATED BY BAG-CHECK DATA FOR 1953 AND 1954[1]

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ABSTRACT

Waterfowl hunter bag checks were made in most of the important shooting reas of the State during the open seasons of 1953 and 1954. The first year, 585 hunters were contacted who had bagged 2,012 birds, while the second ear the figures were 2,929 and 2,944, respectively.

Over the State as a whole, the black duck was the single most important pecies in terms of the number bagged. Among the dabbling ducks, the other ajor species were the wood duck, mallard, and teal. Among the diving ducks, ie principal species were the scaups, redhead, canvasback, goldeneye, and oters.

Hunting success averaged one bird bagged per 4 or 5 gun-hours. It was ghest in the Ontario-St. Lawrence and Long Island regions. Crippling losses mounted to nearly 25 per cent of the ducks bagged, although there was idence that many such birds were actually retrieved by other hunters. Use dogs was found to be a decided advantage with respect to hunting success. lso hunters using blinds were more successful than those who practiced jump ooting or pass shooting. Hunting success on Long Island was increased subntially as a result of the later open season provided by the separate zoning this region instituted in 1953.

The data recorded for sex and age ratios are also given.

Although samples of the hunter harvest of waterfowl during the unning season had been obtained in various regions of the State each ear since 1945, it was not until 1953 that a concerted effort was made check hunters on a statewide basis. Besides providing data on which pecies contributed most heavily to the bag and certain indications of eir status, the study in 1953 and 1954 was designed to furnish inforation regarding relative hunting success in different regions and eas, losses due to crippling, hunting methods employed, and the fects of regulations or other management measures. Banding records ere also gathered as there was opportunity. A prime consideration in ie fall of 1953 was the evaluation of hunting success on Long Island s a result of its being placed in a separate zone from the rest of the tate, with a later open season.

PROCEDURE

In 1953 waterfowl gunners were interviewed on 17 of the most avored hunting areas, and in 1954 on 25 areas. The regions of the

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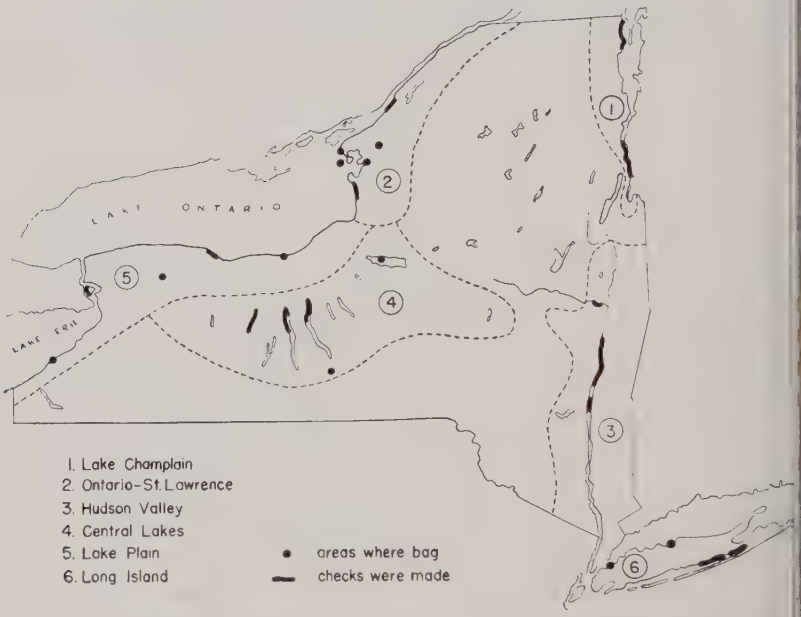

Figure 1. Major waterfowl hunting regions of New York and areas when bag-checks were made in 1953-54.

State covered are shown in Figure 1. The help of the district game managers and their staffs was enlisted, specific areas for checking suggested, and standardized forms and instructions for recording data provided.

The actual recording of data involved interviewing hunters as they left the marsh at the end of their shooting. Often the check points also proved to be good vantage points from which observations could be made to be checked with the gunners later. This was of value especially in assessing the success of gunning by different methods and in cross-checking reports of crippling loss.

In 1953 the season upstate extended from October 17 to December 15, and on Long Island from November 6 to January 4. In 1954 the corresponding periods were October 16 to December 14, and November 3 to January 1, respectively. In 1953, due to the way in which the work was set up, most of the hunters were contacted during the first weekend of legal shooting. In 1954, the data were taken over a longer period and probably a more representative sample was obtained. In spite of this difference, the data provide pertinent comparisons.

FINDINGS

For the several regions of the State, the data reflect the relative importance of the various species to the hunter and the degree of hunting success experienced. They also provide information on crippling loss and the effectiveness of different hunting methods.

RELATIVE IMPORTANCE OF THE VARIOUS SPECIES

Throughout New York State it has been found that the species and relative numbers of waterfowl killed differ according to region, hunting area, and type of hunting. There are also differences in early and late season hunting. Tables 1 and 2 show by region the data recorded during the hunter bag checks in 1953 and 1954.

The composition of the kill has been found to be fairly characteristic for each of the regions, although the apparent discrepancies between years for the Central Lakes and Long Island regions are explained by more thorough coverage of diving duck hunters in 1954. In the Hudson Valley, Ontario-St. Lawrence, and Lake Plain regions dabbling ducks are of predominant importance to the hunter, while in the Central Lakes and Long Island regions the diving ducks usually take precedence. The situation on Lake Champlain is in doubt since too few birds have been examined there, and these mostly at the beginning of the season.

Hunting areas within regions, however, were found to differ widely in the composition of the waterfowl harvest. At Oak Orchard, an interior marsh in the Lake Plain region, the kill consisted almost entirely of dabbling ducks, while on the bays of Lake Erie and Lake Ontario, as well as the Niagara River, within the same region, diving ducks made up the bulk of the harvest. On the Central Lakes proper the open-water species such as redhead, canvasback, and scaup were taken most frequently, but in the marshes at the ends of lakes and on the many smaller marsh and swamp areas nearby, black ducks, mallards, and wood ducks contributed most heavily to the bag. Even in the Hudson Valley, where in the overall picture diving ducks are insignificant, they do provide some shooting in the wider reaches of the river, particularly from Beacon southward.

That the type of hunting should have an effect on the species composition of the bag is obvious since many experienced gunners are specialists according to their preference. Some of the implications, however, are not generally realized. Many wood ducks are taken by jump shooting, which is generally an early-season pursuit in this State,

Table 1. Relative Importance of the Various Species of Waterfowl During the First Few Days of the Open Season in New York in Terms of the Hunter Bag-check in 1953 Showing Regional Differences

Species	Lake Champlain		Hudson Valley		Ontario-St. Lawrence		Central Lakes		Lake Plain		Long Island		Total	
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
Dabbling ducks														
Black duck	11	13.6	436	49.2	162	40.9	26	18.4	36	21.3	165	48.8	836	41.5
Wood duck	7	8.6	192	21.6	59	14.9	8	5.7	40	23.7	1	0.3	307	15.3
Mallard	..	....	96	10.8	95	24.0	47	33.3	33	19.5	26	7.7	297	14.8
Green-winged teal	1	1.2	89	10.0	7	1.8	5	3.6	36	21.3	38	11.2	176	8.7
Blue-winged teal	5	6.2	59	6.7	43	10.9	20	14.2	22	13.0	...	....	149	7.4
Teal sp.	..	....	...	....	1	0.2	...	....	...	....	...	....	1	0.1
Pintail	1	1.2	6	0.7	9	2.3	...	....	...	....	11	3.3	27	1.3
Baldpate	..	....	...	....	3	0.7	4	2.8	...	....	1	0.3	8	0.4
Gadwall	..	....	...	....	...	....	...	....	1	0.6	...	....	1	0.1
Sub-total	25	30.9	878	99.0	379	95.7	110	78.0	168	99.4	242	71.6	1,802	89.6
Diving ducks														
Scaup sp.	48	59.3	...	....	2	0.5	4	2.8	...	....	...	....	54	2.7
Lesser scaup	..	....	...	....	1	0.3	...	....	...	....	41	12.1	42	2.1
Greater scaup	..	....	...	....	9	2.3	2	1.4	...	....	1	0.3	12	0.6
White-winged scoter	..	....	...	....	...	....	...	....	...	....	10	2.9	10	0.5
American scoter	..	....	...	....	...	....	...	....	...	....	1	0.3	1	0.1
Scoter sp.	..	....	...	....	...	....	...	....	...	....	4	1.2	4	0.2
Goldeneye	7	8.6	...	....	...	....	1	0.7	...	....	1	0.3	9	0.4
Redhead	..	....	...	....	...	....	9	6.4	...	....	...	....	9	0.4
Canvasback	..	....	...	....	1	0.3	6	4.3	...	....	...	....	7	0.3
Ruddy duck	..	....	1	0.1	...	....	...	....	...	....	3	0.9	4	0.2
Bufflehead	1	1.2	...	....	...	....	1	0.7	...	....	...	....	2	0.1
Sub-total	56	69.1	1	0.1	13	3.3	23	16.3	...	....	61	18.0	154	7.6
Geese														
Canada goose	..	....	...	....	2	0.5	...	....	1	0.6	11	3.2	14	0.7
American brant	..	....	...	....	...	....	...	....	...	....	10	3.0	10	0.5
Sub-total	..	....	...	....	2	0.5	...	....	1	0.6	21	6.2	24	1.2
Other														
Mergansers	..	....	...	....	2	0.5	2	1.4	...	....	11	3.3	15	0.8
Coot	..	....	8	0.9	...	....	5	3.6	...	....	1	0.3	14	0.7
Unidentified	..	....	...	....	...	....	1	0.7	...	....	2	0.6	3	0.1
Sub-total	..	....	8	0.9	2	0.5	8	5.7	...	....	14	4.2	32	1.6
Total	81	100.0	887	100.0	396	100.0	141	100.0	169	100.0	338	100.0	2,012	100.0

Species	Lake Champlain		Hudson Valley		Ontario-St. Lawrence		Central Lakes		Lake Plain		Long Island		Total	
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
Dabbling ducks														
Black duck	25	21.4	284	41.9	126	27.4	60	10.1	75	14.1	128	22.7	698	23.7
Wood duck	10	8.5	139	20.5	32	6.9	25	4.2	124	23.3	1	0.2	331	11.3
Mallard	....	....	52	7.7	53	11.5	23	3.9	81	15.2	64	11.3	273	9.3
Green-winged teal	2	1.7	70	10.3	38	8.3	11	1.9	61	11.4	15	2.7	197	6.7
Blue-winged teal	8	6.8	54	7.9	71	15.4	16	2.7	21	3.9	4	0.7	174	5.9
Baldpate	....	....	27	4.0	23	5.0	7	1.2	8	1.5	7	1.2	72	2.4
Pintail	....	....	7	1.0	5	1.1	14	2.4	14	2.6	12	2.1	52	1.8
Gadwall	....	....	3	0.4	4	0.9	....	....	....	....	....	....	7	0.2
Shoveller	....	....	2	0.3	....	....	1	0.2	1	0.2	....	....	4	0.1
Black duck X mallard	....	....	....	....	....	....	....	....	2	0.4	1	0.2	3	0.1
Sub-total	45	38.4	638	94.1	352	76.5	157	26.6	387	72.6	232	41.1	1,811	61.5
Diving ducks														
Scaup sp.	58	49.6	....	....	23	5.1	55	9.3	....	....	95	16.8	231	7.9
Greater scaup	....	....	2	0.3	....	....	65	11.0	41	7.7	69	12.2	177	6.0
Lesser scaup	....	....	2	0.3	....	....	6	1.0	8	1.5	42	7.4	58	2.0
Canvasback	....	....	....	....	2	0.4	112	19.0	28	5.3	2	0.4	144	4.9
Redhead	1	0.9	1	0.1	3	0.7	117	19.8	7	1.3	6	1.0	135	4.6
Goldeneye	3	2.6	....	....	27	5.9	16	2.7	26	4.9	1	0.2	73	2.5
White-winged scoter	....	....	....	....	....	....	....	....	....	....	43	7.6	43	1.5
American scoter	....	....	....	....	....	....	....	....	....	....	1	0.2	1	tr.
Surf scoter	....	....	....	....	....	....	....	....	....	....	1	0.2	1	tr.
Scoter sp.	....	....	....	....	....	....	15	2.5	....	....	14	2.5	29	1.0
Bufflehead	....	....	....	....	2	0.4	5	0.9	5	0.9	7	1.2	19	0.6
Ring-necked duck	4	3.4	....	....	1	0.2	3	0.5	2	0.4	....	....	10	0.3
Old squaw	....	....	....	....	2	0.4	3	0.5	....	....	1	0.2	6	0.2
Ruddy duck	....	....	....	....	....	....	....	....	....	....	1	0.2	1	tr.
Sub-total	66	56.4	5	0.7	60	13.1	397	67.2	117	22.0	283	50.1	928	31.5
Geese														
American brant	....	....	....	....	7	1.5	2	0.3	....	....	31	5.5	40	1.4
Canada goose	....	....	3	0.5	1	0.2	4	0.7	8	1.5	10	1.7	26	0.9
Sub-total	....	....	3	0.5	8	1.7	6	1.0	8	1.5	41	7.2	66	2.3
Other														
Coot	3	2.6	32	4.7	5	1.1	23	3.9	20	3.7	2	0.4	85	2.9
Mergansers	3	2.6	....	....	35	7.6	7	1.1	1	0.2	7	1.2	53	1.8
Unidentified	....	....	....	....	....	....	1	0.2	....	....	....	....	1	tr.
Sub-total	6	5.2	32	4.7	40	8.7	31	5.2	21	3.9	9	1.6	139	4.7
Total	117	100.0	678	100.0	460	100.0	591	100.0	533	100.0	565	100.0	2,944	100.0

and the proportion of this species in the total bag is greater than th foregoing figures show because few hunters of this sort were checke The same might be said for both species of teal. Much of the earl season hunting of black ducks, mallards, and other dabblers is als jump shooting, but late season gunning for these species involves blin and decoys. Practically all the diving ducks are taken from blind except in the case of scoters and old squaws which are largely bagge on Long Island by open dory shooting. Many geese are taken inc dentally to other waterfowl shooting, but the most consistent kills a made from upland blinds where the birds feed in grainfields. Therefor it is evident that innumerable local variations occur. Nevertheless, it believed that the kill composition indicated by the data presented broadly representative.

It appears that a better correlation between the actual abundan of birds and the hunting season harvest exists for most of the dabblin duck species than for the diving ducks. At least, this seems to be tru from comparison of bag-check data with aerial waterfowl censu records. Diving ducks characteristically raft in great numbers in com parative safety on the larger water areas. Collectively they may repre sent the largest segment of potential shooting among the waterfow yet they are usually not available to the gun unless weather condition cause them to move inshore.

During the bag-check work records were kept of the sex and ag of as many specimens as possible. Information regarding sex ratio

Table 3. Sex Ratios of the More Important Waterfowl Species a Recorded in the Hunter Bag-check in New York in 195 and 1954

Species	1953		1954	
	Males per 100 females	Number specimens	Males per 100 females	Number specimens
Mallard	79	233	86	226
Black duck	104	595	106	591
Baldpate	100	4	58	63
Pintail	50	9	85	37
Green-winged teal	115	112	132	160
Blue-winged teal	129	87	118	146
Wood duck	136	260	140	274
Redhead	200	9	138	81
Canvasback	100	6	219	83
Greater scaup	71	12	105	123
Lesser scaup	82	31	71	53
Goldeneye	17	7	120	66

TABLE 4. NUMBER OF JUVENILES PER ADULT FOR THE MORE IMPORTANT WATERFOWL SPECIES AS RECORDED IN THE HUNTER BAG-CHECK IN NEW YORK IN 1953 AND 1954

Species	1953*	1954*
Mallard	1.18	1.86
Black duck	1.21	1.64
Baldpate	2.00	3.85
Pintail	1.43	1.06
Green-winged teal	1.89	1.86
Blue-winged teal	1.10	2.48
Wood duck	0.82	1.34
Redhead	2.00	1.25
Canvasback	1.33	1.31
Greater scaup	2.00	2.00
Lesser scaup	1.82	4.89
Goldeneye	0.17	0.89

* Numbers involved for each year and species are the same as in Table 2.

and the relative abundance of adults and juveniles should indicate the condition of the population, especially the success of the most recent breeding season, provided a representative sample was obtained. The figures recorded are given in Tables 3 and 4.

HUNTING SUCCESS

Waterfowl hunting success has been appraised for the various regions and for the State as a whole by calculating the average number of birds bagged per day per hunter and the average number of gun-hours per bird bagged (Table 5). The daily bag per hunter has been in wider use by most waterfowl workers, but the number of gun-hours per bird seems to be a more sensitive indicator if the more accurate data necessary have been taken.

For the various regions of New York, hunting success has differed rather chacteristically. The Long Island and Ontario-St. Lawrence regions have consistently provided the most sport for the least amount of hunting time, while the Hudson Valley and Lake Plain have averaged below the figure for the State as a whole. As mentioned before, the check in the Lake Champlain region was probably the least representative although it did not vary much from one year to the next. The probable reasons for the substantial decrease indicated for the Central Lakes region were the more extensive check in 1954 which included larger proportions of unsuccessful hunters and the effects of hurricane "Hazel" which damaged blinds, docks, and boats, and caused erratic movements among the birds. The reasons for the

Table 5. Summary of Waterfowl Hunting Success by Regions in New York as Recorded by Interview in the Field in 1953 and 1954

Region	Year	Number of hunters checked	Gun-hours	Water-fowl bagged	Shot in		Number of dogs used§	Cripples lost		Banded birds recorded	Gun-hours per bird bagged	Birds bagged per hunter-day
					A.M.*	P.M.*		Number	Per cent			
Lake Champlain	1953	46	271	81	33	1	1	4	4.7	0	3.3	1.8
	1954	71	385	117	33	14	2	43	26.9	1	3.3	1.7
Hudson Valley	1953	737	3,127	887	128	90	25	325	27.4	9	3.5	1.2
	1954	787	3,294	678	86	21	29	302	30.8	7	4.7	0.9
Ontario-St. Lawrence	1953	176	812	396	59	24	31	118	23.0	47	2.1	2.3
	1954	267	1,443	460	114	31	43	135	22.7	3	3.1	1.7
Central Lakes	1953	75	500	141	51	5	3	19	11.9	4	3.5	1.9
	1954	568	3,502	591	210	77	26	123	17.2	3	5.9	1.1
Lake Plain	1953	342	1,813	169	39	12	9	107	38.8	12	10.7	0.5
	1954	939	3,996	533	205	27	39	226	30.0	48	7.5	0.6
Long Island	1953	209	841	338	103	52	23	79	18.9	4	2.5	1.6
	1954	297	1,574	565	218	21	32	88	11.9	7	2.8	1.9
Total	1953	1,585	7,364	2,012	413	184	92	662	24.8	76	3.7	1.3
	1954	2,929	14,188	2,944	866	191	171	917	23.8	69	4.8	1.0

* Not recorded for all hunters; does not include afternoon of first day when season opened at noon.

§ Hunters per dog for all upstate areas averaged 18.9; for Long Island the figure was 9.3; the statewide average was 17.1.

differing degree of success over the State are many. Of primary importance to the success in the Ontario-St. Lawrence region and on Long Island are the great amounts of excellent waterfowl habitat and the large numbers of migrant birds. Other regions may be deficient in attractive habitat that is huntable, have fewer migrants, or support greater hunting pressures.

Of interest to those concerned with waterfowl hunting regulations were the findings of a countrywide survey made a few years ago by the U. S. Fish and Wildlife Service which indicated that the majority of the waterfowl taken were killed during the morning hours. The data obtained during the present bag check show that, of 1,654 birds examined, 1,279 (77.3 per cent) were shot during the forenoon. In none of the six regions did this figure vary more than 12 per cent.

Relation of Crippling Loss to Hunting Success

The loss of waterfowl through crippling during the open season has been of concern to game authorities for many years. The data gathered during the bag-check surveys in 1953 and 1954 are summarized in Table 5. Crippling loss, as the term is used here, means those birds seen to be knocked down and not retrieved, at least not recovered by the same hunter.

This loss, while obviously affecting hunting success by not filling the game bag and yet depleting the huntable population, undoubtedly is not quite so severe as shown. On the opening afternoon in 1954, at Stockport Flats along the Hudson River, 135 birds were knocked down as cripples and not retrieved by the same party, but 79 were recorded as picked up by other hunters. If this were a universal factor by which recorded crippling losses could be discounted, the proportion lost in this way in 1954 would have been only 14.7 per cent instead of the indicated 23.8 per cent.

The aid of retrievers in the reduction of crippling losses was also found to be of some consequence, although probably of more importance in actual hunting success. In Table 6 the figures show, for both years, that the gunners using dogs (about 15 per cent of those checked) were more successful in bagging birds than those without this help. There seems little doubt that the use of retrievers by waterfowl hunters goes hand in hand with more experience, knowledge and better preparation, plus other factors governing the success of a hunt, but it was difficult to obtain any exact information on such points. Nevertheless, it is believed that the use of a good dog plays a large part in filling the game bag as shown by these figures. The fact that not only

Table 6. Comparison of Waterfowl Hunting Success With and Without Dogs, as Indicated by Hunter Bag-check in New York in 1953 and 1954*

Year and item	Number of hunters providing information	Gun-hours	Waterfowl bagged	Cripples lost	Gun-hours per bird bagged	Cripples lost per gun-day	Birds bagged per gun-da
1953							
With dogs	222	994	508	100	2.0	0.5	2.3
Without dogs	1,273	6,002	1,369	562	4.4	0.4	1.1
1954							
With dogs	446	2,332	627	171	3.7	0.4	1.4
Without dogs	2,481	11,840	2,311	746	5.1	0.3	0.9

* Total figures for each year in this table differ somewhat from the correspon ing totals in Table 5 because information regarding dogs was not obtain from all hunters checked.

were more birds taken on the average by gunners with dogs than b those without, but also that this was accomplished in less time spe afield, argues well for the wider use of good retrievers. The recorde data do not actually show any reduction in crippling loss for the do owners over the non-owners, but it was the feeling of most technician on the survey that the former seemed much less loathe to divulge suc information.

Effect of Zoning on Long Island

Between 1900 and 1953 the waterfowl season on Long Island ha been separate from and later than that of the rest of the State on 3 occasions, but from 1935 to 1952 (with the exception of 1937) it ha been coincident with that upstate. During these years dissatisfactio was voiced by many Long Island duck hunters, who felt that a wate fowl season, opening there as early as is most desirable upstate (mid October), was not in the best interests of either the gunners or th birds. However, with national waterfowl populations at a low lev through most of this period, little heed was paid to these com plaints. Immediately after World War II duck abundance began t increase, and this, together with more complete knowledge gained fro aerial observations and an intensive investigation of the waterfo situation on Long Island made by this Department, resulted in separate and later season for this region in 1953 and 1954. To evalua the effect of the later season, opening early in November, the da collected in these years are compared to records for 1949 and 195

TABLE 7. COMPARISON OF WATERFOWL HUNTING SUCCESS ON LONG ISLAND DURING SEASONS OF EARLY OPENING* AND OF LATER OPENING§

Year	Number of hunters checked	Gun-hours	Waterfowl bagged	Gun-hours per bird bagged	Birds bagged per hunter-day	Composition of bag in per cent		
						Dabbling ducks	Diving ducks	Geese and others
1949	82	342	101	3.4	1.2	84	7	9
1950	89	499	70	7.1	0.8	99	1	0
1953	209	841	338	2.5	1.6	72	18	10
1954	297	1,574	565	2.8	1.9	41	50	9

* October 21, 1949 and October 20, 1950.
§ November 6, 1953 and November 3, 1954.

Table 7). It seems evident that hunting success was markedly better under zoning, especially for diving ducks. It is felt that the harvest came more nearly at the peak of abundance with probably less adverse effect upon any one segment of the population than would have been the case with an earlier season.

Effects of Other Regulations

In recent years each change in regulations has been watched closely for its effects on the waterfowl population. In 1953, besides the separate zoning of Long Island, shooting until sunset was allowed. Previously, all shooting had to cease 1 hour before sunset. Sample checks were made on a few hunting areas to determine the effects of later shooting. The data collected in 1953 are given in Table 8, and are considered to be representative since essentially similar figures were obtained in 1954 also.

During the years when closing was 1 hour before sunset, it was the usual thing for the ducks to begin to return to a marsh about the time the hunters had returned to their cars, even on opening day. Much grumbling was heard at the checking stations as the birds were seen to drop in, in pairs and small flocks, to the same areas just vacated by the gunners. In 1953, with shooting permitted until sunset, fair numbers of waterfowl began to return during open hunting hours. These birds provided good shooting opportunity, and many hunters were satisfied. In many instances, however, this opportunity was minimized by "sky-shooters" who, shooting at birds far out of range, spoiled it for everyone. On the second day, the fewer birds that did drop in

Table 8. Proportion of Waterfowl Taken During the Last Lega Hour of Shooting on the First Two Days of the Ope Season in 1953

Area*	Date	Total birds taken	Taken in last hour	
			Number	Per cent
Hudson Valley	October 17	446	49	11.0
	October 18	158	9	5.7
Bays west of Rochester	October 17	43	4	9.3
	October 18	8	0	0.0
Oak Orchard	October 17	28	3	10.7
	October 18§	...	..	....

* On Long Island, where the season opened November 6, no exact data we taken, but from observations it appeared that about 10 per cent of the fir day's kill was taken during the last hour and that the percentage was near as great the second day.

§ No data recorded.

came nearly too late to shoot. After that, the ducks had learned to sta away until nightfall, and the situation was as it had existed formerl This pattern was observed both upstate and on Long Island, and, whi it might seem that not much was achieved by the extra shooting hou it did provide considerable additional hunting opportunity at a tim when the greatest concentrations were afield. It probably did no result in any excessive kill of waterfowl, but it may have made la enforcement more difficult. The small additional harvest seems to hav been justified, and it served a good purpose in public relations.

Success of Various Hunting Methods

The three chief types of waterfowl hunting practiced in this Stat are blind shooting, pass shooting, and jump shooting. On the basis o information obtained in 1953 and 1954 the relative numbers usin each method and their success were determined (Table 9). Oth specialized types of gunning are done, such as open dory shooting fo scoters and old squaws, but these were not sampled to any extent.

The gunners using blinds (usually with decoys) were the mo successful by far each year, especially during 1954 when success b all methods dropped under what it had been the year before. In 195 hunters using blinds took home nearly three times as many birds a did others. The success of jump and pass shooters seemed to be abou on a par each year. The latter types of waterfowl gunning seem to b particularly wasteful of the resource, in downing many birds as cripple

TABLE 9. WATERFOWL HUNTING SUCCESS ACCORDING TO HUNTING METHOD AS RECORDED DURING THE HUNTER BAG-CHECK IN NEW YORK IN 1953 AND 1954

Year	Hunting method									Total		
	Blind shooting			Jump shooting			Pass shooting					
	Number of hunters checked	Birds bagged per gun-day	Per cent crippling loss	Number of hunters checked	Birds bagged per gun-day	Per cent crippling loss	Number of hunters checked	Birds bagged per gun-day	Per cent crippling loss	Number of hunters checked	Birds bagged per gun-day	Per cent crippling loss
1953	545	1.85	17.3	236	1.17	31.3	298	1.21	27.8	1,079	1.53	22.4
1954	1,438	1.45	18 2	213	0 49	41 9	912	0.52	33.3	2,563	1.04	22.6

which are not easily retrieved in dense vegetation. This is especia true of the early shooting on such dabblers as wood ducks and te Part of the high success enjoyed by hunters using blinds is no dou accounted for by the comparative ease of bringing cripples to b

DISCUSSION AND CONCLUSIONS

For most of the problems to which the bag-check data app comparable information could not be obtained by a type of "harve study where personal contact in the field would be sacrified. Pos questionnaires might offer a larger volume of data, but the formation would be neither as complete nor as reliable. Few gunn keep accurate records of the numbers of waterfowl killed and few still remember them as to species. Sex and age data would be alm useless, as would, for instance, records of the number of banded bi taken and not reported. An example of the degree to which hunt fail to report banded birds may be cited from data obtained on Lo Island in 1949 and 1950. In checking hunters during both years. L banded birds were recorded. No special emphasis was given these bi during the interviews, so the normal course of reporting or not repo ing by the hunter should have occurred. As it turned out, a check the returns received showed that only 35 per cent of the bands kno to have been recovered were reported to the U. S. Fish and Wildl Service. Factors such as these are important to know in any study hunting pressure and population turnover, and indicate the value data gathered by personal contact in the field.

There has been some question regarding the value of figures sex ratio and age ratio obtained through bag checks of this kind. So after the development of the method for accurately determining and age by cloacal examination, it was believed that reliable apprais of yearly production could be made. However, the fact that f workers obtained what were considered reasonable data caused dou as to its applicability. The variations in sex and age ratios record for the same species in different localities, however, may actually the clue to the value of this technique, in that they may be associat with sub-populations having differential migratory behavior. Furth study along these lines, particularly the banding of juveniles on t breeding grounds, should clarify the matter. In any case, an und standing of the reasons behind these sex and age variations from pla to place and year to year, beyond those accounted for by inexperienc technicians, seems important to progress in waterfowl manageme

The 1953-54 bag-check records corroborate other observations in dicating that the waterfowl species of greatest importance to the unter in New York are the black duck, wood duck, mallard, and teal nong the dabbling ducks, and the scaups, red head, canvasback, ldeneye, and scoters among the diving ducks.

During these seasons hunters, on the average, bagged one bird er 4 or 5 gun-hours. Crippling losses amounted to nearly 25 per cent the ducks bagged, although there was evidence that many such rds were actually retrieved by other hunters. Use of dogs was found be a decided advantage with respect to hunting success. Also unters using blinds were more successful than those who practiced mp shooting or pass shooting. Hunting success on Long Island was creased substantially as a result of the later open season provided by e separate zoning of this region instituted in 1953.

AN ELECTRICAL SURFACE DEVICE FOR CARP CONTROL AN FISH COLLECTION IN LAKES[1]

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ABSTRACT

An electrical surface device was constructed and tested to determine th relative effectiveness of moving electrode devices in capturing various speci of fish, especially carp. It consisted of four electrodes suspended from th corners of a scow and powered by a 230 volt alternating current generato Experiments under different conditions in a variety of types of habitat a described and the characteristics of the electric fields created are presente The data also apply to underwater equipment such as the deepwater traw

The surface device proved to be effective for collecting fish on a sma scale, especially in weedy and stumpy areas. Observations indicated that larg fish are more easily shocked than smaller ones, but are more capable of evadi the electric fields. Electrical devices of this type are inefficient as means controlling fish populations by capture.

Experiments were undertaken to determine the effectiveness an characteristics of an underwater, alternating current electrical trav for collecting fish in lakes. The trawl consisted of a bag net attache to a 5-foot-square, electrified frame which was towed 100 to 300 fe behind a boat. An additional pair of electrodes was hung about 2 feet in front of the frame. This device had originally been tested i Oneida Lake (Haskell, 1955) with some degree of success. Later tes in a small, deep (up to 45 feet), soft-bottomed lake indicated a nee for mechanical improvement and electrical definition of the devic These tests resulted in catches of yellow perch, bullheads, and golde shiners. Pickerel, largemouth bass, brown trout, sunfish, and sucker which also inhabited the lake, were not taken. In general, fish caug were the smaller individuals, which appeared to indicate that th larger fish were avoiding the device (possibly by chance). The ver fact that small fish (less than 4 inches) were taken was an indicatio of relative effectiveness of the electrical fields produced in the wate Nevertheless, the extent of the field around each electrode wa unknown as were the activities of the fish in relation to these movin fields. Accordingly, a surface device was constructed, operated exte sively, and defined electrically.

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[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project F-9-R The author wishes to acknowledge the helpful advice of David C. Haskell i connection with the preparation of this paper. Roderic Freeman supervise the resistivity and paralysis voltage tests.

The underwater trawl was intended as a fish collection and possible control device; primarily, it could be an additional tool for fishery biologists. If effectively operated, enough fish might be taken to provide good material for age and growth work, population studies, and similar investigations. The surface device constructed was intended to be electrically similar to the underwater trawl and somewhat resembles a device used in Illinois (Laramore *et al.*, 1950). The device was tested on Lamoka Lake (approximately 600 acres). The majority of fish collected were carp, and most of the observations were of carp reactions. The definition of the voltage fields was suggested by Haskell's (1954) determination of the voltage required for paralysis in relation to size of fish.

MECHANICAL COMPONENTS OF THE SURFACE DEVICE

The surface device is partially illustrated in the accompanying illustrations. It consisted of four electrodes suspended from four wooden booms extending from the four corners of a wooden scow. The device was powered by a Homelite generator producing 230 volt alternating current. The front and rear electrodes on the same side of the boat were of similar polarity. The scow was approximately 16½ feet in length and 5 feet in width and was powered by a 10 h.p. motor. Each electrode could be operated independently.

The front electrodes were solid brass rods, ½ inch in diameter and approximately 7½ feet in length. The rear electrodes were made of braided copper cable slightly over ½ inch in diameter and approximately 7 feet long.

When the boat was at rest in water over 7 feet in depth, all four electrodes hung straight down with 6 to 6.5 feet of each submerged. The front electrodes were 9.2 feet apart; the rear ones, 11.5 feet apart. The front pair were separated from the rear pair by a distance of 7 feet.

The lengths of the electrodes were considered to be adequate for maximum voltage efficiency. Their shapes allowed movement of the boat through the thickest vegetation. When the boat was in motion, all four electrodes swung back at an angle due to water resistance. In shallow water they rested on the bottom or on vegetation.

OPERATION OF THE DEVICE AND OBSERVED REACTIONS OF FISH

The device was operated on Lake Lamoka for portions of nine days from June 22 to July 15, 1954. During the period about 100 carp

were taken which ranged from a few ounces to 12 pounds in weigh The average weight of these fish was 7 pounds, or about ½ poun larger than that of 170 carp seined from Lake Lamoka betwee August 6 and 13. This may have been a reflection of the selectiv action of electrical devices, which more readily incapacitate the larg fish.

Only about a quarter of the shocked fish seen could be retrieve Probably many others were shocked but not seen.

The relative inability of the device to incapacitate fish perma nently was amply illustrated. Specific areas in channels could b repeatedly shocked at 15-minute intervals, and carp of all sizes cou be raised each time. Dead fish were never seen, even in shallow wate Intentionally prolonged shocking (2 minutes) of a group of 20 spawn ing carp failed to kill the fish immediately, although they might hav died later. All of these fish were lying on their sides and moving feeb 2 hours after the shock. Incidentally, with an additional jolt at th time each fish moved a short distance—enough to make the ar turbid and prevent its capture.

Most of the shocking was carried out after the carp spawnin season. Possibly a great many more fish could have been retrieve from shallow water during the spawning season.

Catches of 200 to 300 pounds per hour have been taken fro Crab Orchard Lake in Illinois (Laramore *et al.*, 1950). However, w were unable to take more than that amount in 6 to 8 hours shocking.

The device was operated in every type of available habitat various times of the day and night and in various types of weathe Few carp were taken from areas where pondweeds (chiefly *Potom geton robbinsii*) formed extensive subsurface mats. Beyond that, ca appeared to be everywhere and anywhere.

Fish of all sizes reacted in what appeared to be erratic fashio although general patterns could be distinguished. Generally speakin the fish appeared to dash about until they were either out of the fie or stopped by a strong portion of it. A few incapacitated fish floate for a few seconds, but more often they sank at once. The reactions carp were especially noticeable at night under spotlight.

A few large fish (seen during a few chance observations in cle water) on the fringe of the measurable field (25 feet from the boa appeared to be warned by the electric current or by the approach the boat itself. Quick flight of large, "resting" carp did coincide wit the sudden application of current in two instances. Similar reactio

ere noted during development of electrical devices in Michigan Applegate *et al.*, 1952).

A large, partially shocked fish may often move with enough itial force to carry it 10 or 12 feet. This reaction may take it in any irection. If the fish remains or swims between the electrodes of an nderwater trawl, the net will retrieve it. Similarly, it can be retrieved y a surface device if it comes within reach. If the fish swims downard, it is lost; if upward, it may sometimes be retrieved; if to the de, back, or front, it may remain out of sight and reach, and thus ay evade the field and recover rapidly. The less affected fish usually cape unless they blunder into the electric field.

Mention should be made of the fact that pulsation of an alterating current was tried. Tests were cursory and too limited to warrant nclusions. However, no increase or decrease in the number of fish ocked was noted, but it does seem possible that the surprise factor pulsation would be compensated for by the escape of fish while e current was off. Non-pulsating, 110 volt, direct current was also ed briefly, but with no success.

Fish were retrieved by scoop net, spear, and spring gaff. Only very few large fish other than carp were visibly incapacitated and ly a few of these were retrieved. They consisted mainly of largeouth bass and chub suckers. Pickerel were abundant but never seen the electric field; probably certain alert and fast moving species oided the device. Speeds of the underwater trawl and the surface vice were estimated at 3 and 6 feet per second (2 and 4 miles per ur), respectively. Wales (1950) estimated the speed of 12-inch stern suckers at 10 feet per second for about 5 seconds, and quoted e speed of 13-inch trout as being about 11 feet per second. Obously, most 12-inch fish have the ability to avoid an electrical device oving at a speed of less than 8 to 10 miles per hour and could probly "side-step" faster moving rigs. Hundreds of thousands of small h (mostly fry) were incapacitated by the front electrodes (and prenably by the rear electrodes also), and many could have been rieved.

Retrieving of stunned fish is not a leisurely activity. As an average, ee of four fish stunned and seen are not captured for one or more the following reasons.

1. Missed by spear, gaff, or net.
2. Passed too rapidly by boat.
3. Appeared only momentarily in turbid water.
4. Had to be left by operator busy with another fish.

5. Recovered before being reached by boat.
6. Carried out of sight by movement of fish itself.

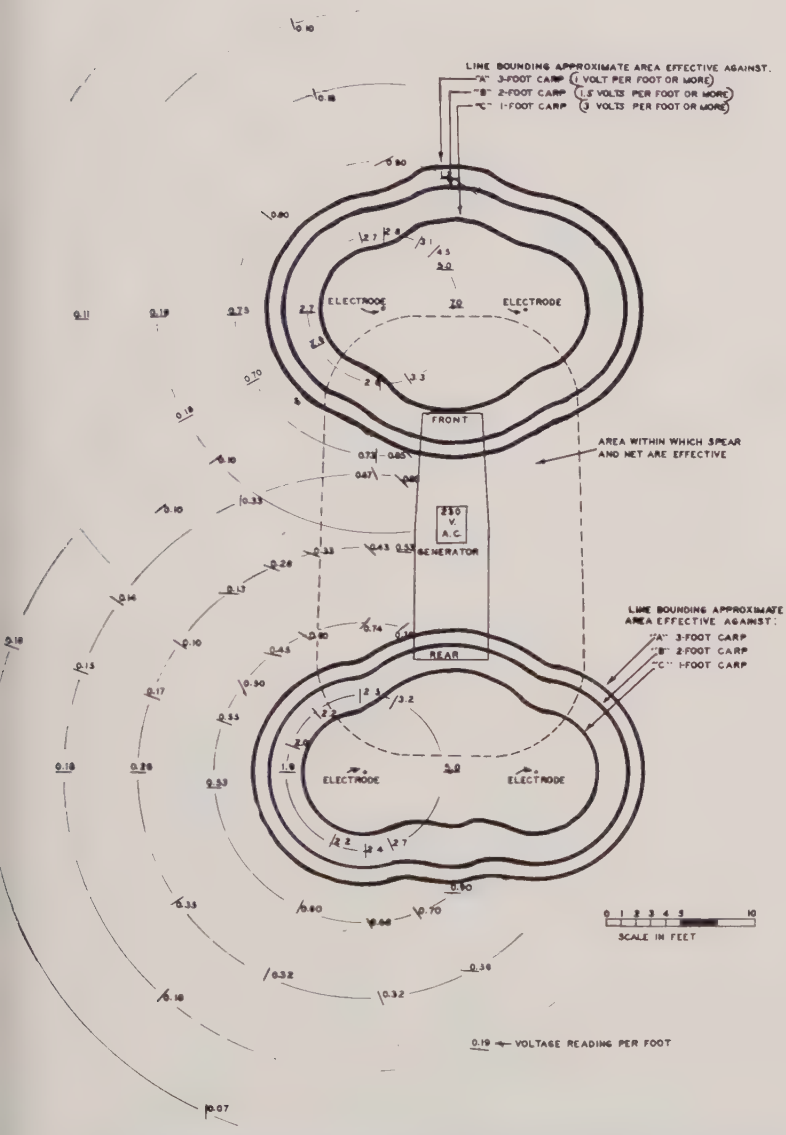
Manual retrieving of the fish is inefficient at best. A number collection devices were considered in theory but all would have creased the initial cost of equipment and labor or impeded the progr of the boat. Additional electrodes, for example, could be power only by a larger generator.

VOLTAGE GRADIENTS

When the boat was in motion, all four electrodes trailed at angle from the vertical as shown in Figure 2. The voltage gradients the water around each electrode were, however, determined while t boat was anchored securely and the electrodes hung in a verti position. Voltages were read from another boat with a probe ma from two copper terminals placed 1 foot apart. All values are e pressions of the number of "volts per foot" for the parts of the circ measured. Each measurement is an expression of the greatest volta per foot which could be found on a horizontal plane in a column water 1 foot in diameter and extending from the surface to a dep of 3 feet. Voltage readings were obviously not extremely accurate d to movement of the boat, but they are considered suitable for defini the practical extents of the electrical fields. Frequent rechecks w made. Readings were taken from a Heathkit Multimeter, Model MM having a sensitivity of 20,000 ohms per volt for direct current an 5,000 ohms per volt for alternating current. Although an outsi source of power was necessary for deflection of the needle, error thought to have been slight.

Figures 1, 2, and 3 clearly illustrate the fact that even a lar carp must be relatively close to an electrode before it can be i capacitated.

Figure 1 is a schematic representation of the electrical fields wh all four electrodes were in operation. Contour lines "C" represent gradient of 3 volts per foot. These lines are drawn by estimate betwe the actual voltages taken. Since approximately 3 volts are required incapacitate any carp immediately, a fish 1 foot in length could quickly paralyzed only within the area bounded by the "C" lines; fish 2 feet long could be incapacitated within the "B" lines represen ing a voltage gradient of 1.5 volts per foot; a fish 3 feet long could incapacitated within the "A" lines representing a voltage gradient 1 volt per foot.


LINE BOUNDING APPROXIMATE AREA EFFECTIVE AGAINST.
"A" 3-FOOT CARP (1 VOLT PER FOOT OR MORE)
"B" 2-FOOT CARP (1.5 VOLTS PER FOOT OR MORE)
"C" 1-FOOT CARP (3 VOLTS PER FOOT OR MORE)
ELECTRODE
ELECTRODE
FRONT
AREA WITHIN WHICH SPEAR AND NET ARE EFFECTIVE
230 V A.C.
GENERATOR
REAR
LINE BOUNDING APPROXIMATE AREA EFFECTIVE AGAINST:
"A" 3-FOOT CARP
"B" 2-FOOT CARP
"C" 1-FOOT CARP
ELECTRODE
ELECTRODE
0 1 2 3 4 5 10
SCALE IN FEET
0.19 ← VOLTAGE READING PER FOOT

gure 1. Relationships among the electrical fields surrounding the four vertical electrodes of the fish collecting device studied, using 230 volt alternating current. The short line accompanying each reading represents a distance of 1 foot in the direction of the strongest flow of current at that point. Doubling input voltage would increase distances between electrodes and lines "A" less than 5 feet.

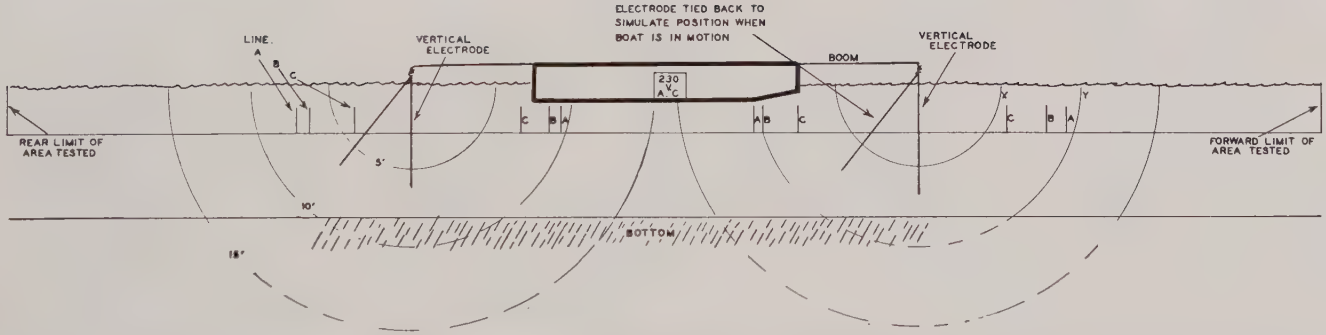
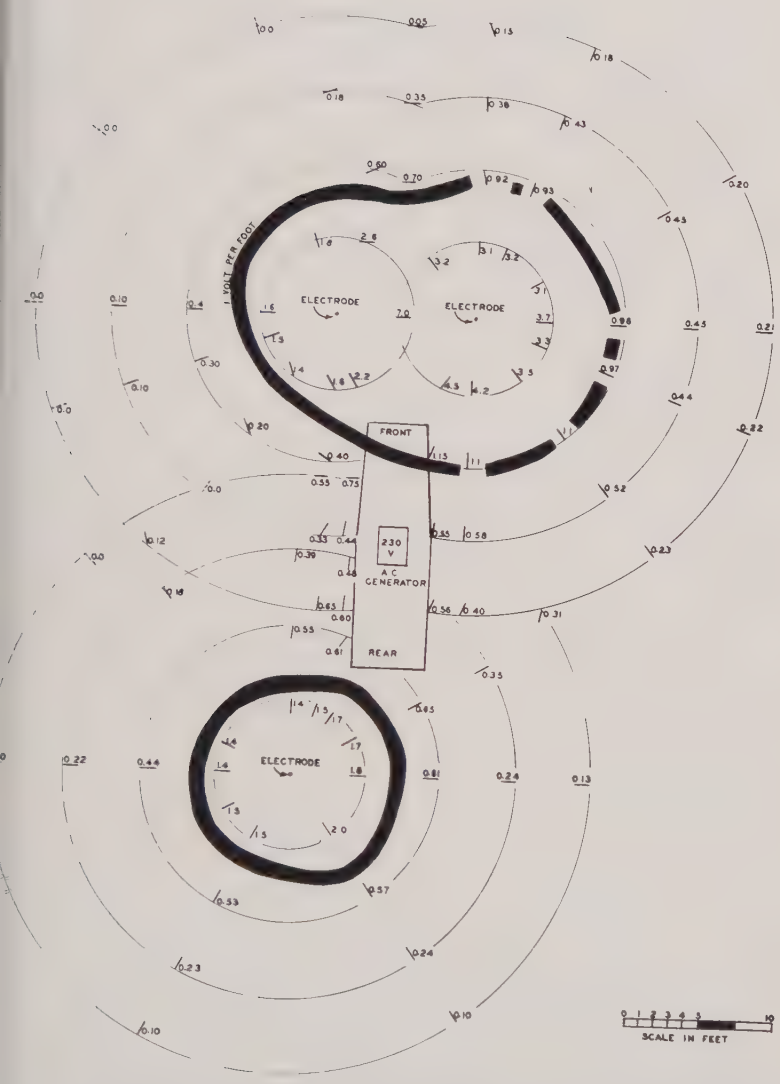


Figure 2. Profile of Figure 1 showing relationships of contour lines "A", "B", and "C" to a depth of 3 feet. Voltage gradients dropped considerably at points *X* and *Y* when electrodes were tied back from the vertical position.



gure 3. Voltage gradient per foot taken around three operating electrodes, left front and rear being of similar polarity. A carp 3 feet in length would be immediately incapacitated at or within the areas bounded by the heavy lines. Despite the fact that the voltage readings around the right front electrode are greater than illustrated in Figure 1, the effective shocking radius is only slightly larger.

From Figure 1 it can be seen that no fish 36 inches or less i length could be immediately incapacitated at a distance of more tha 8 feet from an electrode. Doubling the voltage output of the gen erator would double every voltage reading in Figure 1. Lines "A would then move out to a distance approximately 10 or 11 feet fro the electrodes. This voltage (460 volt A. C.) is probably higher tha advisable for safety and impractical from a generator standpoint.

The dotted line in Figure 1 bounds the area within which fis can be effectively retrieved by men in a boat, a distance of 6 to 7 fee

Figure 2 presents a side view of the areas of incapacitation to depth of 3 feet only, since voltages were not tested below that depth When the front electrodes were tied back at the approximate angl shown, readings at points X and Y (5 and 10 feet in front of the pre vious vertical setting, respectively) were greately reduced. The readin at point X dropped from 2.8 volts per foot to 0.8 volts per foot. Thes readings were the greatest which could be obtained by the probe a any angle, from the surface to a depth of approximately 3 feet. Ob viously, the effective portion of the field, as illustrated in Figure 1. i reduced ahead of the front electrodes when the boat is movin forward.

Figure 3 illustrates the extent of the electrical fields when on electrode (right rear) is not functioning. The field surrounding th other electrode of similar polarity (right front) is strengthened whil those surrounding the others (left front and rear) are weakened.

When front or rear electrodes were operated alone, voltage read ings were generally similar to those illustrated in Figure 1.

RESISTIVITY OF CARP FLESH

The resistance of carp flesh was found to be approximately 1,47 ohms per centimeter cube at 53° F. The fish tested was a carp, 1 inches long, and was alive during the entire test. The water used wa Rome Hatchery spring water, with a resistance of 5,400 ohms pe centimeter cube at the beginning of the test. Resistances of water, and probably of fish, are less at higher temperatures. The method of testing was that employed by Haskell (1954). He found the resistivity o brown trout flesh to be approximately 1,500 ohms per centimeter cub at a temperature of 53° F. The agreement between the brown trout and carp flesh resistivity figures might be coincidental; it suggests, however, that all fish flesh (fresh-water) might have similar resistivities. The difference between the values of 1,470 and 1,500 may have been entirely due to the coarseness of the meter dial.

The immediate practical application of a knowledge of resistivi-s is evident. If all fish flesh has approximately the same resistivity, d if other conditions, such as electrode setup, be equal, it is possible work out a table of values illustrating the voltage gradient per foot cessary in water to produce equal voltages on a 12-inch fish of any ecies. Required voltages are much lower in waters of low resistance, ch as sea water.

The resistivity of Lake Lamoka water at the time of the tests is known. The resistance of water collected on December 21, 1954 is 5,540 ohms per centimeter cube at 70° F. Assuming a somewhat nilar resistivity during late June, this moderately hard water was obably a good conductor of electricity.

During the tests to determine the resistivity of carp flesh, voltage adings indicated that about 1.1 volts per foot would be required to oduce 1.0 volt on a 12-inch fish. This figure applies only at water sistivities of approximately 5,000 ohms per centimeter cube. The ference is due to distortion of the electric field as described by askell (1954). Accordingly, lines "A", "B", and "C" in Figure 1 ould be closer to the electrodes if their definitions were changed to ontours of voltage gradients per foot per fish".[2] Thus, the effective lds are actually smaller than indicated. Furthermore, the softer the ater, the smaller the size of the electric field in which fish may be apacitated.

PARALYSIS VOLTAGE

Haskell (1954) found that 3.1 ± 0.3 volts of alternating current r fish were required to paralyze hatchery brown trout ranging from to 11 inches in total length. By use of his method, a voltage of proximately 3.0 was found to be effective against active carp at a mperature of 53° F. These values show close agreement with Mc-illan's findings (1928) which showed that a 3.1 inch chinook salmon could not be paralyzed by a voltage gradient of less than 1.23 volts r inch in water of high resistivity. The voltages on carp were read the instant of paralysis using probes placed on the extremes of the . Sixteen carp, ranging from 12.5 to 18 inches in length were used. he general condition of the fish may be described as ranging from y weak to quite active. Data from about 50 observations were corded.

[2] Voltage gradient per fish is defined as the reading obtained when probes are placed on the extremities of a fish in an electrical field.

Although many more observations would be necessary for possibl confirmation, the following conclusions are offered. A fish is alway stimulated to movement by an application (on the fish itself) of alter nating current voltages of intensities ranging from approximately 1 t 3 volts per fish. This movement always carries the fish in a forwar direction. Voltages per fish of less than 1 may or may not discomfi the fish.

At voltages of 2.8 to 3.2 active carp were stopped after sligh movement and forward motion of one to several inches. After a few seconds recovery, the same effect could be produced by a lesser voltage Active carp could also be stopped by low voltages of about 1.5 per fish after movement of several feet during a large fraction of a second. Weak carp could be stopped more quickly with initial voltages of 1.4 to 1.8 per fish.

At a gradient of 3.3 volts per fish an active 17-inch carp was immobilized without visible movement, after which the fish recovered (at least temporarily). A jolt of 5.2 volts per fish similarly stiffened an active 12.5-inch carp which did not recover.

Within limits, therefore, it appears that the period of time and the distance moved before incapacitation are inverse to the amount of voltage per fish. Both apparently decrease and are less in the case of fish in poor condition and fish subjected (after recovery of a few seconds) to succeeding, equal jolts. Distance moved before incapacitation increases with size of fish involved, and possibly with higher temperatures.

Hauch (1949) described the harmful effects of electric shock on large rainbow trout. No doubt, the writer's observations could also be defined physiologically with much greater accuracy than that afforded by visual observations.

CONCLUSIONS

The surface device proved to be the best available tool for collecting fish from stumpy, weedy areas. Large fish (other than pickerel) and fry were especially vulnerable. Fish ranging from 3 to 12 inches in length can also be taken with manually operated dip nets.

The small size of the effective electrical fields in the water is a distinct limiting factor, probably applicable to the underwater trawl also. Expense and inefficiency prohibit the use of such a device for fish control purposes.

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MOVEMENT OF WATERFOWL HUNTERS IN NEW YORK STATE[1]

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ABSTRACT

The movement of waterfowl hunters in pursuit of their sport was studied by means of hunter bag checks in 1953 and 1954, and by analysing band returns for 1953 and previous years. Data from both sources indicated that over 70 per cent of the gunners hunted within 25 miles of home. Also, few hunters traveled from one zone to the other in New York to take advantage of the two separate opening days.

For 15 years prior to 1953 the waterfowl season for Long Island had opened concurrently with that of upstate New York. During the fall of 1953 the waterfowl regulations provided two zones. Upstate the season opened October 17 and closed December 15, while on Long Island it extended from November 6 to January 4. The same zones were used in 1954 and the corresponding dates were October 16 to December 14 and November 3 to January 1, respectively. Zoning, although it more nearly equalized hunting opportunity by opening the season in each case during the period of most rapid build-up in waterfowl numbers, presented some new management problems. Would duck hunters over the State take advantage of the two separate opening days? How far would these gunners travel in their pursuit of waterfowl?

PROCEDURE

To provide answers to these questions, as well as to obtain other valuable information, statewide hunter bag checks using Department personnel were conducted in the fall of 1953 and again in 1954. This consisted of contacting hunters in the field on most of the better hunting areas and recording a variety of information, including their home addresses. In this way both their hunting grounds and their point of origin would be known. Other information, on a regional basis, had been taken in former years and provided some background for this study.

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[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project W-39-R.
The authors wish to acknowledge the fine effort and help of all 23 technicians who participated in the hunter check.

In 1953 most of the checks were made during the first weekend of the season in each zone. Altogether, 1,585 hunters of all types, both successful and unsuccessful, were interviewed, of whom 1,456 were willing to give their addresses. In 1954 checks were made each weekend throughout the entire season and 2,929 hunters were contacted of whom 2,705 gave their addresses.

In addition to the hunter bag check, considerable information on hunter movement was available in the records of duck band returns. The band recovery forms received from the U. S. Fish and Wildlife Service generally give the exact location where the bird was taken as well as the address of the hunter making the report. Only hunting season recoveries were used in this study. Band returns from birds taken in 1953 and from those taken in former years (chiefly 1951 and 1952) were compared to determine the change hunters might have made to take advantage of zoning.

The information from both sources (bag check and band returns) was compiled by regions of the State (Figure 1). The distances between the hunters' homes and their hunting areas were broken down

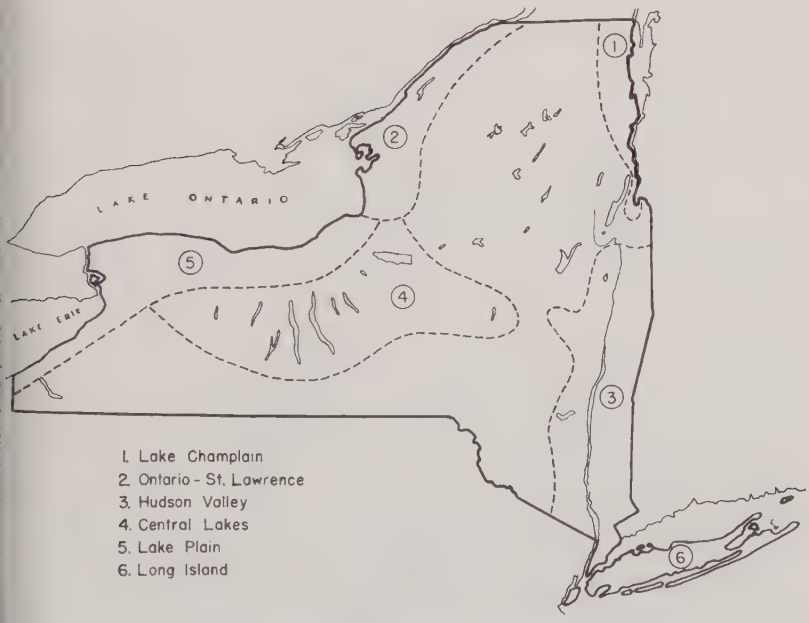

Figure 1. Major waterfowl hunting regions of New York State.

into the following classes: (1) within 25 miles, (2) 26 to 50 miles (3) over 50 miles, (4) out-of-zone, and (5) out-of-State.

FINDINGS AND DISCUSSION

The data obtained through the hunter bag check are shown in Tables 1 and 2. They indicate that nearly 70 per cent of the gunner contacted in both years hunted within 25 miles of home. The Hudson Valley was the only region which seemed to interest an appreciabl number of out-of-zone hunters. This would be expected since it i closest to the Long Island zone. Most of these hunters came from New York City and the densely-populated western section of Long Island From regional studies this situation was known to exist. Very few upstate hunters traveled to Long Island for the later opening day o afterward. There were probably two main reasons for this. First, muc of the zeal for gunning would have already been dissipated during th upstate seasons (for both waterfowl and upland game) by the tim the later opening rolled around. Second, most of the choice huntin grounds on Long Island are either posted entirely or, in certain town ships, the sportsman must hire a resident guide. In no other regio

Table 1. Distance Travelled by Waterfowl Hunters in New Yor State by Region, as Indicated by the 1953 Hunter Bag Chec

Region	Distance from home to hunting area										Tot
	0–25 miles		26–50 miles		Over 50 miles		Out-of-zone		Out-of-State		
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	
Lake Champlain	30	71.4	..	..	12	28.6	..	..	..	..	4
Ontario-St. Lawrence	98	66.7	12	8.1	37	25.2	..	..	..	..	14
Hudson Valley	512	78.5	45	6.9	22	3.4	70	10.7	3	0.5	65
Central Lakes	31	44.9	24	34.8	14	20.3	..	..	..	..	6
Lake Plain	197	57.6	141	41.2	4	1.2	..	..	..	..	34
Long Island	139	68.1	41	20.1	19	9.3	5	2.5	..	..	20
Total.....	1,007	69.2	263	18.1	108	7.4	75	5.1	3	0.2	1,45

TABLE 2. DISTANCE TRAVELLED BY WATERFOWL HUNTERS IN NEW YORK STATE BY REGION, AS INDICATED BY THE 1954 HUNTER BAG CHECK

Region	Distance from home to hunting area										Total
	0–25 miles		26–50 miles		Over 50 miles		Out-of-zone		Out-of-State		
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	
Lake Champlain	45	80.4	6	10.7	5	8.9	..	..	..	..	56
Ontario-St. Lawrence	189	72.7	10	3.8	60	23.1	..	..	1	0.4	260
Hudson Valley	380	52.9	233	32.5	70	9.7	23	3.2	12	1.7	718
Central Lakes	393	84.2	35	7.5	38	8.1	1	0.2	..	..	467
Lake Plain	569	62 3	317	34.7	27	3.0	..	..	..	..	913
Long Island	224	77.0	15	5.1	45	15.5	5	1.7	2	0.7	291
Total	1,800	66 5	616	22 8	245	9 0	29	1.1	15	0.6	2,705

was more than one gunner checked who was from out-of-zone or out-of-State.

Sportsmen originating over 50 miles from the hunting grounds in the Ontario-St. Lawrence region came largely from cities in the central part of the State, principally Syracuse, Rome, and Utica. Those in this category gunning Lake Champlain originated mostly in the Albany-Troy-Schenectady section. Hunters from over 50 miles away in the Central Lakes and Lake Plain regions came from the larger cities within these regions as well as from the larger cities in the Southern Tier.

Even though the checking was limited by necessity to weekends and only a small proportion of the hunters afield were contacted, this type of check was valuable. It provided the broadest possible cross-section of gunners obtainable and would reveal any important hunter movement. The beaver pond hunters, and those who shoot on small marshes and potholes, perhaps incidentally to upland game hunting, were not sampled to any great extent, but it is believed that most of these gunners would be extremely local.

The information from the 1953 band returns is given in Table 3. These figures show that nearly 90 per cent of the gunners who re-

Table 3. Distance Travelled by Waterfowl Hunters in New Yo State by Region, as Indicated by Band Returns for 1953

Region	Distance from home to hunting area										To
	0–25 miles		26–50 miles		Over 50 miles		Out-of-zone		Out-of-State		
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	
Lake Champlain	19	86.4	..	..	1	4.5	..	..	2	9.1	
Ontario-St. Lawrence	53	84.1	1	1.6	9	14.3	..	..	..	..	
Hudson Valley	85	96.6	1	1.1	1	1.1	1	1.1	..	..	
Central Lakes	116	93.6	3	2.4	3	2.4	1	0.8	1	0.8	
Lake Plain	126	92.0	6	4.4	5	3.6	..	..	..	..	
Long Island	222	84.4	4	1.5	23	8.8	6	2.3	8	3.0	
Total.....	621	89.1	15	2.2	42	6.0	8	1.1	11	1.6	

turned these bands traveled less than 25 miles to hunt. Very fe hunters moved from one zone to the other to take advantage of t two opening days. Although this information is derived from t returns on 697 banded birds, it quite possibly represents a differe cross-section of hunters from that obtained on the bag check. All the hunters were obviously successful, and they also proved their willin ness to report bands. Furthermore, these returns were made throughc the season rather than only at the start as was the case for the b check in 1953. Thus, this sample might be expected to reflect t more experienced or dyed-in-the-wool gunners to a greater exte Regardless of the possible differences inherent in the two kinds data, the findings as to hunter movement are remarkably similar.

The chief difference between the data from the two sources, i that for the percentages of hunters who gunned within 25 miles fr home, might mean that duck hunters will travel farther to reach cho hunting spots on opening day than later in the season. It might a mean that the more successful gunners are those who consistently hu close to home all season. However, when the percentages obtain from the two sources are compared by combining the figures for t first two distance categories there is much closer agreement, nearly

per cent for the bag check data and 91 per cent for the band returns. This seems to indicate that differences for the "0 to 25 miles" group may have been more apparent than real, and might be explained by difficulty in plotting the point of origin exactly.

Several factors contributed to the recorded travel of over 50 miles by hunters in going to their hunting grounds. A number of hunters checked in the Ontario-St. Lawrence region actually came from central New York, but they had summer camps in the vicinity and hunted from these. They may have been close to these camps but over 50 miles from home. A similar situation existed in the Lake Champlain region with respect to hunters from the Hudson Valley. A unique situation was found on Long Island, where many gunners in the region live on the Island and commute to work in New York City. Quite often the business address was the one given on the band return, accounting for an "over 50 miles" designation. In a few cases where the home address was known, it proved to be less than 25 miles from the hunting site. It was impossible to determine all of this information

TABLE 4. DISTANCE TRAVELLED BY WATERFOWL HUNTERS IN NEW YORK STATE BY REGION, AS INDICATED BY BAND RETURNS FOR YEARS (CHIEFLY 1951 AND 1952) PRIOR OF THE ESTABLISHMENT OF ZONES

Region	Distance from home to hunting area										Total
	0–25 miles		26–50 miles		Over 50 miles		Out-of-zone		Out-of-State		
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	
ake Champlain	53	96.4	..	..	2	3.6	..	..	..	..	55
ntario-St. Lawrence	127	90.7	..	..	8	5.7	3	2.2	2	1.4	140
udson Valley	103	92.8	2	1.8	3	2.7	..	..	3	2.7	111
entral Lakes	152	96.8	2	1.3	3	1.9	..	..	..	..	157
ake Plain	106	98.2	1	0.9	1	0.9	..	..	..	..	108
ong Island	342	82.4	5	1.2	60	14.5	3	0 7	5	1.2	415
otal.....	883	89.6	10	1 0	77	7.8	6	0.6	10	1.0	986

from the band return records, and this may account for some of the differences between the data in the tables.

To get a picture of what the movement of duck hunters might have been in years before the State was zoned, and for direct comparison with the situation in 1953 and 1954, band returns from ducks taken chiefly in 1951 and 1952 were tabulated. Table 4 gives the breakdown by regions of this information.

The 1951-52 data, during years of no zoning, show a pattern of hunter movement similar to that indicated by the returns for 1953 and 1954 when zoning was in effect. Although percentagewise a few more hunters on Long Island came from out-of-zone or out-of-State during the last two years, the numbers were too small to be significant.

CONCLUSIONS

Analysis of the data recorded indicates that at least 70 per cent and perhaps as many as 90 per cent. of New York waterfowl gunners hunted within 25 miles of their homes. The data also indicate that the hunters did not move appreciably from one zone to the other to take advantage of the two separate opening days. From a management standpoint, the small amount of shifting that did take place was not important, and from previous band return data and earlier bag checks it appears that this minor hunter shift has prevailed for some time.

SOME OBSERVATIONS ON THE BREEDING BEHAVIOR OF DEER

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ABSTRACT

Six instances of fatal attacks on does by bucks during the breeding season among deer held in captivity are reported. The genital tracts of five of the six does were examined. The relationship of ovulation to the peak of the estrus period, when a doe becomes receptive, appears to be quite inconsistent. It seems that does may cause vigorous sexual stimulation in bucks for at least 3 days prior to receptiveness and for at least 2 days after mating. Thus it would appear that an individual doe might attract a buck's continuous and ardent attention for a period of at least 5 or 6 days.

The white-tailed deer is one of the most beautiful animals on the North American continent. Its buoyancy in motion, grace in form, and statuesque poise challenge our admiration. The buck is a handsome beast, proud and defiant. His courting antics, however, are seldom chivalrous for ". . . he is no single-hearted gentleman during the rut. In fact, he is no gentleman. He bullies and mauls his mate. He's insane with the spirit of the mad-moon" (Carhart, 1946).

Physiologically, a mature buck is able to mate successfully from early September through February and, for some individuals, into March. Actual mating, however, is determined by the doe's estrus cycle and her period of acceptance. Does approaching this period are recognized by bucks and are often chased by them, the intensity of the pursuit depending on the progress of estrus. Sometimes two or more bucks will follow the same doe. T. S. VanDyke knew of well-authenticated cases in which three or four, and on one occasion seven, bucks were shot in less than 15 minutes as they followed, one after the other, along the trail of a doe in heat (Newsom, 1926, p. 49).

The true ferocity of the buck during this period is seldom realized in the wild because the doe manages to elude her pursuers. However, in pens this is not always possible. C. Bathgate Becker maintained a deer corral of about 2 acres near Stamford, New York. In the fall of 1945 one of his bucks began chasing a doe but she would not stand. Her evasiveness only seemed to anger the buck and on the morning of the fourth day she was found disemboweled. This act apparently did not satiate his madness because he also killed a second doe for which he previously had shown no serious interest.

Similar incidents have occurred in the deer pens at the Wildlife Research Laboratory at Delmar, New York. In one instance three

adult does were gored to death during the same night by a buck name Ichabod. On a second occasion an adult doe was gored to death b another buck.

In each of these six instances of fatal attack on does by buck the blood on the buck's antlers, head and neck indicated each ha struck with insane ferocity. Similar evidence of violence was seen i the bruises from neck to rump and in the punctures of hide and the muscles between the ribs of the does.

Of interest is the fact that all of these bucks were fully matur perhaps even past their prime. Since they had originally been obtaine as fawns, their ages were definitely known. Becker's buck was 7½ yea old. In the triple death at Delmar, Ichabod was 8½ years old, and i the sixth instance the buck was 7½ years old. Each had been a goo breeder during earlier years. Becker's buck was destroyed after h deadly "mad". Ichabod was held until the next year. Again, he demon strated dangerous violence against a doe and he was isolated imm diately. Two days afterward the doe was successfully bred by anoth buck.

Examination of the genital tracts of five of the six does was po sible. In the Becker case the doe was within a few hours of ovulatin when she was killed. (The other doe was not examined.) In Ichabod case, one doe had ovulated just prior to or as she was being kille The second doe was within a few hours of ovulating, and the third ha large egg follicles developing but probably would not have ovulated f several days. In the last instance the doe had ovulated within a da prior to death judging from the condition of the ovary. This conditio was observed by the author and confirmed by J. R. Reilly and E. L Cheatum.

The relationship of ovulation to the peak of the estrus perio when a doe becomes receptive, appears to be quite inconsistent. Eac of the five does examined was killed before she would stand for servic In two cases ovulation had already occurred, in two it was pendin within a few hours, and in the other it would not have taken place fo several days. On the other hand, Cheatum and Morton (1942) re ported an instance in which a doe was observed to accept a buc although examination (she was sacrificed for the purpose 13 hou later) showed she had not ovulated.

The estrus period has been described as lasting from 24 to 3 hours (Cheatum, 1949). However, does may cause vigorous sexua stimulation in bucks for at least 3 days prior to receptiveness and fo at least 2 days after mating. Thus it would appear that an individua

oe might attract a buck's continuous and ardent attention for a eriod of at least 5 to 6 days.

To what extent this may actually occur in the wild is unknown. Because, in the northern range of the white-tail, nearly 70 per cent of he breeding each fall takes place during the last 3 weeks of Novem- er, taking individual bucks out of circulation for several days could e an important factor in the productivity of a deer population having n abnormally unbalanced sex ratio.

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USE OF AGE COMPOSITION DATA FOR DETERMINING SEX RATIOS AMONG ADULT DEER[1]

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ABSTRACT

In studying the productivity of a species, a knowledge of sex ratios is important. A method of deriving a reasonable approximation of the sex ratio among the adults in a deer population is described. It depends on concurrent random sampling of the adults of each sex, accurate determination of the age of the deer in the samples, and a basis for equating the proportions of males and females among the yearlings prior to the time of sampling. Stated briefly, the ratio of the percentages of yearlings in separate samples of the two sexes (corrected for any inequality in the sex ratio among the yearlings) is the inverse of the sex ratio among the adults as a whole.

In studying the productivity of a species, a knowledge of sex ratios is important. For deer under present conditions in New York, if the sex ratio among the yearlings in a population is known, the percentages of yearlings in separate random samples of each sex may be used to derive the sex ratio among the adults as a whole. Thus a measure of this factor may be obtained even though the actual samples are different in size. Why this is so may not be readily clear. Accordingly, a brief explanation is given.

Considering first a population prior to the hunting season in which there are equal numbers of males and females among the yearlings, let:

a = number of yearling males
b = number of yearling females
X = total number of adult males[2]
Y' = total number of adult females[2]

Then:

$\frac{a}{X}$ = percentage of yearling males
$\frac{b}{Y}$ = percentage of yearling females

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[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project W-28-R.

[2] Includes yearlings.

And:

$$\frac{a}{X} \div \frac{b}{Y} = \text{ratio of the two percentages} = \frac{a}{X} \times \frac{Y}{b}$$

Since it has been assumed that $a = b$, $\frac{a}{X} \times \frac{Y}{b} = \frac{Y}{X}$ which represents the ratio of males to females in the total adult population. In practice, the inverse operation of dividing the percentage for males by that for females to get a ratio of males to females is an apparent paradox.

Having derived the foregoing formula, the use of sample age composition data may be discussed. It has been shown (Maguire and Severinghaus, 1954) that the deer shot during the open season in New York constitute a random sample of the prehunting-season population and that, in turn, the records from checking stations operated concurrently may be considered representative of the legal kill. Therefore, when hunting is permitted for both antlered and antlerless deer, the percentage of yearlings in the sample for each sex would be the same as that in the population from which it came. Under actual field conditions the sex ratio among the yearlings would seldom, if ever, be exactly even. Not only is there a differential at birth but various influences may affect the sexes unequally between then and the fall of their second year when they are sampled as yearlings. If, however, a reasonable estimate of the ratio for this age class at the time of sampling can be derived, the figures for the two sexes among the yearlings in the sample can be equated and the respective values substituted for the terms $\frac{a}{X}$ and $\frac{b}{Y}$ in the formula and the sex ratio among the adults as a whole determined. The actual size of either sample would be immaterial so long as it was random, although it is felt that in using checking station data the sample should represent at least 10 per cent of the total kill. It must be emphasized again, however, that the procedure is not valid unless the ratio of the two sexes among the yearlings in the population before the open season is known, at least approximately. For example, if the sex ratio at birth was known and it was believed that no differential mortality occurred during the first year and a half, then the same sex ratio could be assumed for the yearlings.

To help visualize the population dynamics that make this sex ratio determination possible, the growth and trend in age composition of a hypothetical deer population are given in Table 1. To save space, 109 male and 100 female fawns (corresponding to the best available estimate of the sex ratio at birth) were used to begin with. This same

Table 1. Hypothetical Growth of White-tailed Deer Population Showing Trend of Sex Ratio and Effect of Taking Antlerless Deer in 11th and 12th Years

Year and item*	Fawns		Sex distribution by year class among adults																				Total adults		Males per 100 females among adults
			1		2		3		4		5		6		7		8		9		10		11				
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	
1st year	109	100																					..	..	..
Legal kill	..	..																					..	..	..
Remainder	109	100																					..	..	..
2nd year	18	16	109	100																			109	100	109.0
Legal kill	..	..	98	..																			..	..	..
Remainder	18	16	11	100																			11	100	11.0
3rd year	92	84	18	16	11	100																	29	116	25.0
Legal kill	..	..	16	..	10	..																	..	..	..
Remainder	92	84	2	16	1	100																	3	116	2.6
4th year	118	109	92	84	2	16	1	100															95	200	47.5
Legal kill	..	..	83	..	2	..	1	..															..	..	..
Remainder	118	109	9	84	..	16	..	100															9	200	4.5
5th year	198	181	118	109	9	84	..	16	..	100													127	309	41.1
Legal kill	..	..	106	..	8	..	..	..	..	..													..	..	..
Remainder	198	181	12	109	1	84	..	16	..	100													13	309	4.2
6th year	308	282	198	181	12	109	1	84	..	16	..	100											211	490	43.1
Legal kill	..	..	178	..	11	..	1	..	..	..	..	..											..	..	..
Remainder	308	282	20	181	1	109	..	84	..	16	..	100											21	490	4.3
7th year	487	447	308	282	20	181	1	109	..	84	..	16	..	100									329	772	42.6
Legal kill	..	..	277	..	18	..	1	..	..	..	..	..	..	..									..	..	..
Remainder	487	447	31	282	2	181	..	109	..	84	..	16	..	100									33	772	4.3
8th year	768	704	487	447	31	282	2	181	..	109	..	84	..	16	..	100							520	1,219	42.7
Legal kill	..	..	438	..	28	..	2	..	..	..	..	..	..	..	..	..							..	..	..
Remainder	768	704	49	447	3	282	..	181	..	109	..	84	..	16	..	100							52	1,219	4.3
9th year	1,212	1,112	768	704	49	447	3	282	..	181	..	109	..	84	..	16	..	100					820	1,923	42.6
Legal kill	..	..	691	..	44	..	3	..	..	..	..	..	..	..	..	..	..	..					..	..	..
Remainder	1,212	1,112	77	704	5	447	..	282	..	181	..	109	..	84	..	16	..	100					82	1,923	4.3
10th year	1,912	1,754	1,212	1,112	77	704	5	447	..	282	..	181	..	109	..	84	..	16	..	100			1,294	3,035	42.6
Legal kill	..	..	1,091	..	69	..	4	..	..	..	..	..	..	..	..	..	..	..	..	..			..	..	..
Remainder	1,912	1,754	121	1,112	8	704	1	447	..	282	..	181	..	109	..	84	..	16	..	100			130	3,035	4.3
11th year	3,017	2,769	1,912	1,754	121	1,112	8	704	1	447	..	282	..	181	..	109	..	84	..	16	..	100	2,042	4,789	42.6
Legal kill	1,131	1,038	1,721	657	109	417	7	264	1	168	..	106	..	68	..	41	..	31	..	6	..	38	..	..	..
Remainder	1,886	1,731	191	1,097	12	695	1	440	..	279	..	176	..	113	..	68	..	53	..	10	..	62	204	2,993	6.8
12th year	2,976	2,731	1,886	1,731	191	1,097	12	695	1	440	..	279	..	176	..	113	..	68	..	53	..	10	..	62	2,090	4,724	44.2
Legal kill	1,116	1,024	1,697	649	172	411	11	261	1	165	..	105	..	66	..	42	..	26	..	20	..	4	..	23	..	..	..
Remainder	1,860	1,707	189	1,082	19	686	1	434	..	275	..	174	..	110	..	71	..	42	..	33	..	6	..	39	209	2,952	7.1

ratio was also applied to the calculated progeny each year. Because it has been found that, on the better quality range in New York, a substantial proportion of the female fawns breed successfully during their first fall, progeny from this group are shown for the second year and are included in the total figures thereafter. The rates of productivity used, 0.34 for does bred as fawns and 1.71 for older does, were derived from the work of Cheatum and Severinghaus (1950). A 12-year longevity for deer not taken by hunting was assumed because it is not unusual for deer to live that long if they have adequate nutrition and protection from other causes of violent death. Deductions from the population were made only for losses from legal hunting. It was assumed that, for the first 10 years, only bucks 1½ years old or more could be taken and that the proportion was 90 per cent. For the eleventh and twelfth years it was assumed that 37.5 per cent of all antlerless deer (including fawns of both sexes) were taken in addition to the removal of adult bucks at the same rate as before. In each case the harvest was applied randomly throughout the age classes present.

Some comment may be made regarding the mortality factors used. The rates of hunting loss were arbitrary. That of 90 per cent for adult bucks is somewhat higher than would be expected under average circumstances. It was selected in order to create a wide difference in the sex ratio in a short period of time. That of 37.5 per cent for antlerless deer is more nearly average. In neither case would the use of different values have changed the relationships bearing on the subject of this paper. Also, it was most unrealistic to omit from the calculations any losses from other causes of mortality, but they would have merely complicated the picture without affecting the features involved here. They have been disregarded, therefore, in the interest of simplicity.

The figures for the first 10 years in Table 1 illustrate the rapid growth of a population in which mortality is limited to the adult males. They show how the average age for the females increases, especially when only the adults are considered. It may be noted, too, that the sex ratio for the adults, both before and after the open season, becomes stabilized between the seventh and ninth years and would remain so indefinitely if the assumed sex ratio at birth and rates of reproduction and mortality did not change. The table also demonstrates the controlling influence of the fawn crop each year as well as the high proportion of the population represented by the yearlings. Similarly, with respect to the eleventh and twelfth years, it shows graphically why the taking of antlerless deer limits population growth.

As has been pointed out, the method of determining sex ratios under consideration requires random samples[3] of both sexes among the adults during the same period. In the hypothetical example, such data are given for the last two years. Using those for the twelfth year, the number of yearling males in the sample (legal kill) is 1,697 and that of yearling females is 649. Because, for this age class, the proportion of males in the prehunting-season population is assumed to have been 109 per cent of that of females, the two sample figures may be equated by dividing 1,697 by 1.09 giving a value of 1,557 for the yearling males. For the respective samples the percentages of yearling males and females would be 82.8 and 36.6. Substituting these in the formula, a value is obtained for the number of females per male among the adults as a whole as follows:

$$\frac{82.8}{36.6} = 2.26$$

This is the same as the corresponding value obtained directly from the population totals.

This method of analysis affords a means of economically obtaining a reasonable approximation of the sex ratio of a deer population. It depends on concurrent random sampling of the adults of each sex, accurate determination of the age of the deer in the samples, and a basis for equating the proportions of males and females among the yearlings prior to the time of sampling.

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[3] Random sampling means that, for each sex, all deer in each age class have an equal chance of being taken and recorded. Conditions, such as regulations setting a minimum antler size for legal game, may preclude the possibility of a random sample.

GENERAL NOTES

FAWN WEIGHTS IN RELATION TO REGULATIONS FOR TAKING ANTLERLESS DEER

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New York State Conservation Department

In another paper elsewhere in this issue the author has presented the weights of deer recorded from two wilderness areas in the Adirondacks during an open season when both antlered and antlerless deer could be taken. The data are given in Table 2 of that paper. The weight relationship between fawns and adults bears on the question of legally prohibiting the taking of fawns during open seasons for antlerless deer.

The range of weights by age for the two sexes is shown in the accompanying graph. The degree of overlap is of particular interest. The heavier fawns of both sexes outweighed the lighter does of all ages as well as many of the younger adult males. In the weight range between 50 and 88 pounds fell 124 (71.7 per cent) of the male fawns and 112 (64.7 per cent) of the female fawns, and, among the adults, 137 males (22.5 per cent) and 307 females (46.7 per cent). Thus a majority of the fawns could have been mistaken for small adults.

This overlapping shows that weight would not be a reliable index for differentiating between fawns and adults. It also shows that, if the taking of fawns were prohibited during an open season for antlerless deer, many small adults would be passed up as fawns and many large fawns would be shot for adults and left in the woods. The degree of overlap is undoubtedly greater in a population occupying poor range, such as the areas involved here, than in one on range of high quality. Nevertheless, the data clearly demonstrate that, where the deer population exceeds the carrying capacity of its range and where the adults average small in size because of competition for an inadequate supply of winter food, the protection of small deer, supposedly fawns, during an open season for antlerless deer would not be advisable.

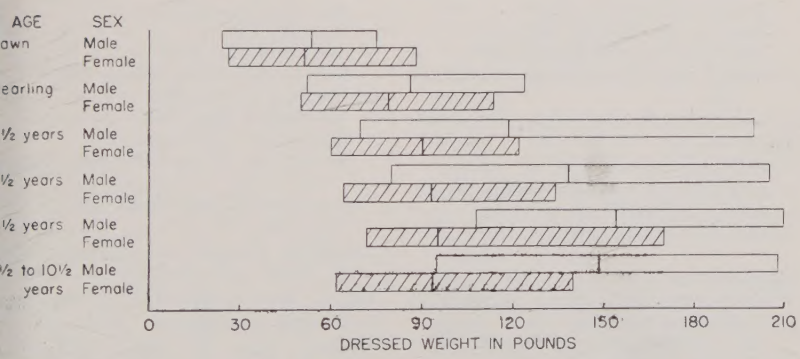

Figure 1. Weight range of white-tailed deer from two wilderness areas in the Adirondacks in 1954. With respect to the yearling males, the graphed range does not include one atypical 165-pound individual, since none of the other 207 specimens exceeded 124 pounds. For each bar, the average is indicated by a transverse line.

Adelman, William J., Jr., see Haskell, David C., 95

Bass, rock, toxicity of rotenone to, 61
Bass, smallmouth
  age and growth, 83
  toxicity of rotenone to, 48, 57
  weight, 91
Bullhead, brown, toxicity of rotenone to, 59
Burdick, G. E., *et al.* Toxicity of emulsifiable rotenone to various species of fish, 36-67

Carp, control of, 220
Chub, creek, toxicity of rotenone to, 43, 56
Climate, characteristic of game range divisions, 127
Control
  carp, 220
  water chestnut, 173
Cook, Arthur H., see Hamilton, W. J., Jr., 13
Cooper, A. L., see Lipschuetz, M., 194
Cuprocyanide, potassium, toxicity to black-nosed dace, 194
Cyanide, potassium, toxicity to black-nosed dace, 194

Dean, Howard J., see Burdick, G. E., 36
Deer
  as food of fisher, 30
  breeding behavior, 239
  hunting regulations, 247
  hypothetical productivity, 244
  weight as index of range conditions, 154
  weight in relation to age, 156, 247
Duck, wood
  nest-box mortality, 75
  production on small marshes, 68
  survival of ducklings, 81
  use of nest boxes, 68

Electric current
  alternating and direct currents in fishery work, 106
  effect of pulsations on fish, 95
Electric fields
  reaction of fish to, 220
  relation to fish shockers, 224

Fish
  reaction to electric current, 95, 106
  reaction to electric fields, 220
  toxicity of rotenone to, 36
  also, see various species
Fisher
  food and feeding habits, 24
  management, 33
  parasites, 32
  pelt values, 18
  recorded take in New York, 18
  reproduction, 30
  sex ratio, 22
  size and weight, 19
  status in New York, 14
Fish shockers
  alternate-polarity electrode, 114
  electric trawl, 120
  surface device, 220
Foley, Donald D. Certain aspects of waterfowl hunting in New York as indicated by bag-check data for 1953 and 1954, 205-219
  also, see Schierbaum, Donald L., 232
Food habits
  fisher, 24
  young salmon, 168
Forney, John L., see Webster, Dwight A., 106

Game distribution in New York, according to game range division, 127
Game range divisions in New York
  Adirondack, 128
  Appalachian Plateau, 133
  Catskill, 138
  Coastal Plain, 140
  Erie-Ontario Lake Plain, 132
  Hudson Valley, 136
  Mohawk Valley, 137
  Ontario-St. Lawrence, 130
  Rensselaer Plateau-Taconic Mountain, 135
  Southeastern Highland, 139
  Tug Hill, 129
Geduldig, Donald, see Haskell, David C., 120
Gibbs, Robert H., Jr., see Webster, Dwight A., 106
Greeley, John R. Effect of size at planting on survival and time of downstream migration of Atlantic salmon in a tributary of Lake

George, 161-172
Survivals of planted Atlantic salmon in Lake George, 1-12
Growth
bass, smallmouth, 83
menhaden, 146
salmon, 169

Hamilton, W. J., Jr. and Arthur H. Cook. The biology and management of the fisher in New York, 13-35
Harris, Earl J., see Burdick, G. E., 36
Haskell, David C. and William J. Adelman, Jr. Effects of rapid direct current pulsations on fish, 95-105
Haskell, David C., Donald Geduldig and Edward Snoek. An electric trawl, 120-125
Herbicides, use in water chestnut control, 179
Hunting, waterfowl
crippling loss, 213
effect of zoning, 214, 232
hunting success, 211
methods, 216
movement of hunters, 232
regions in New York (map), 206, 233
relative importance of various species, 207

Klein, Harold G. Wood duck production and use of nest boxes on some small marshes in New York, 68-83

Lipschuetz, M. and A. L. Cooper. Comparative toxicities of potassium cyanide and potassium cuprocyanide to the western black-nosed dace (*Rhinichthys atratulus meleagris*), 194-204
Loeb, Howard A. An electrical surface device for carp control and fish collection in lakes, 220-231
Long Island, effect of zoning for waterfowl hunting, 214, 232

Management
carp control, 220
deer, 245, 247
fisher, 33
salmon, 172
water chestnut control, 191
waterfowl, 218, 232
Marsh, small, wood duck production on, 68
Migration
salmon, 161
menhaden, 149
Menhaden
growth, 146
importance of fishery, 142
mass mortality, 150
parasites, 152
seasonal movement, 149
spawning, 149
Mortality, menhaden, 150

Nigrelli, Ross F., see Westman, James R., 142

Parasites
fisher, 32
menhaden, 152
Petty, A. C. An alternate-polarity electrode, 114-119
Population composition
deer, 156
salmon, 7
waterfowl, 207
Porcupine, as prey of fisher, 27
Productivity, hypothetical, deer, 244

Raccoon, as prey of fisher, 29
Range conditions
deer, 154
also, see game range
Reproduction
fisher, 30
menhaden, 149
Rotenone, toxicity
comparison in acid and alkaline waters, 42
relation to temperature, 51
to fish, 36

Salmon, Atlantic
management, 172
migration, 161
population composition, 7
size, 7, 169
stocking, 1, 164
survival of planted stock, 1, 161
Salmon, landlocked, see Atlantic salmon
Scheirbaum, Donald L. and Donald D. Foley. Movement of waterfowl hunters in New York State, 232-238
Severinghaus, C. W. Deer weights as an index of range conditions on two wilderness areas in the Adirondack region, 154-160
Fawn weights in relation to regulations for taking antlerless deer, 247
Some observations on the breeding behavior of deer, 239-241
Use of age composition data for determining sex ratios among adult deer, 242-246

Severns, Jack H., see Webster, Dwight A., 106
Sex ratio
deer, 242
fisher, 22
waterfowl, 210
Smith, Ralph H. Definition of game range divisions in New York, 127-141
Experimental control of water chestnut in New York, 173-193
Snoek, Edward, see Haskell, David C., 120
Soils, characteristic of game range divisions, 127
Stocking, Atlantic salmon, 1, 164
Sucker, common, toxicity of rotenone to, 58
Suttkus, Royal D. Age and growth of a smallstream population of "stunted" smallmouth black bass, *Micropterus dolomieu dolomieu* (Lacépède), 83-94

Techniques
alternate-polarity electrode, 114
determining sex ratios among deer, 242
determining toxicity of chemicals to fish, 36, 194
electric trawl, 120
equipment for producing pulsating direct current, 103
Trout, brown, toxicity of rotenone to 46, 62

Van Woert, William F., see Webste Dwight A., 106
Vegetation, characteristic of gam range divisions, 127

Water chestnut
control of, 173
description, 174
history in New York, 173
insect pests of, 185
life history, 183
viability and seed germination, 183
Waterfowl
age ratio, 211
composition of hunter bag, 207
sex ratio, 210
also, see hunting
Webster, Dwight A., *et al.* A compar son of alternating and direct cu rents in fishery work, 106-113
Weight
bass, smallmouth, 91
deer, as an index of range cond tions, 154
deer, in relation to age, 156
fisher, 19
Westman, James R. and Ross I Nigrelli. Preliminary studies menhaden and their mass mortal ties in Long Island and New Jers waters, 142-153